THE GLASS INDUSTRY

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THE GLASS DIVISION AT PITTSBURGH

Large attendance and diversified technical papers mark Glass Division sessions during 46th Annual A. C. S. Meeting.

The technical sessions of the Glass Division, held April 4 and 5 during the 46th annual meeting of the American Ceramic Society at the Hotel William Penn, Pittsburgh, brought out a very large attendance and a wealth and variety of papers. Two hundred persons were present at the Tuesday sessions, and 174 were served at the business luncheon. J. F. Greene, Kimble Glass Company, was in the chair, and he handled the long program without hitch or switch. K. C. Lyon, Armstrong Cork Company, succeeded as program chairman in getting together reporters and reports on a number of phases of glass technology, and grouping them to excellent advantage. The plethora of papers made necessary a sub-division on optical glass, which overflowed the parlors assigned to it on Wednesday afternoon and wound up in the Pittsburgh Room.

Mr. Lyon becomes chairman of the Division for the coming year. The program will be in the capable hands of the new Vice-Chairman, Louis Navias, General Electric Company. S. R. Scholes, N. Y. S. College of Ceramics, continues as Secretary. Under changes in the Rules, Division officers will now be elected by letter ballot. The Division voted to hold a Summer Meeting in 1944, at a place to be selected later.

Discussions were by no means commensurate with the papers presented, either in character or in volume. A part of the reluctance of the members about rising to argue may be laid to shyness about speaking extempore before so large a group; part arises from unfamiliarity with the subject matter presented, often startlingly new. However, discussion tends to be stifled when long papers are read in full from manuscript, and the listeners feel that so much time has been consumed that none remains available for question or debate.

Since abstracts of the papers appear elsewhere in these columns, we shall do no more here than attempt to give a general view of the program, with a few highlights.

The Tuesdays morning session dealt with the physics and chemistry of glasses. Glass in the electronics industry becomes a vital material in this field that is so important in military communications, and will be increasingly important in radio and television for civilians. Metals for conduction and glass for insulation must be joined to stay, and to leak neither electricity nor gases. Selection, composition, welding, and inspection have been developed into a special technique, amazing in its competence . . . Fluorine is named from the same root-word as flux, and now it achieves utility in a bottle glass for that very purpose. So does phosphorus pentoxide, although our predecessors in glassmaking thought of both these reagents chiefly as whiteners.

The Glass Convention Badge. Conceived and produced by Carl J. Urhmann of the Imperial Glass Co.

That marvel of applied physical chemistry, Vycor, was described by one of its inventors. It seems that when the fluxes have played their part in making silica fusible and workable, these mental athletes just ease them out, shrink down the porous article by heating it, and there is a piece of glassware, essentially fused silica. That sounds quite simple, but the accomplishment took years to perfect.

Cords ought not to be stringy, but spherical, if surface tension did the business. It is too feeble a force, overshadowed by all the movings about that happen to a mass of glass between dog-house and bottle. The proponents of the surface-tension ideas will have opportunity for rebuttal. . . . The teaser knows that he cannot see bottom at the dog-house. When a colored glass is in the mould or on the pipe, the glassworker finds it quite opaque. It was interesting to see just how fast transmission of visible light fell off, when glasses containing various colorants were warmed nearly to redness. As for transmission of invisible heat radiation, some say this and some say that. We look for future reports on this interesting topic.

The afternoon program was intended for the operating

men. Stones, cords, decolorizing, and pots are troubles and sources of trouble, historically and forever (we pessimistically hope). A treatise on stones catalogued almost as many as there are blocks in a tank, but the idea seems to be: never mind, because the microscope man will identify each one and call it by name and say where it came from; when the perfect tank is built and the ideal batch materials are found, there will be no more stones. The review of knowledge on cords brought up for emphasis the newer technique of studying them by density difference and strain patterns. The notion of temperature differences as sources of cords was given a severe set-back. Evidence points to differences in chemical composition as the fact that makes cords apparent in the matrix glass.

Officers—Secretary Scholes, Vice-Chairman Navias and Chairman Lyon.

Classical necessities for well-decolorized pot glass—pure raw materials, oxidation, and proper balance of decolorizing reagents—came in for emphasis. Some attention was given to the theory of color by selective absorption, and to the use of proper lighting in judging color. . . The glasshouse pot itself, which has not changed much in many years, has come in for critical study by some practical glassmakers, who feel sure that more strenuous and better-controlled arching will do much for pot performance, and that some sort of protective lining should reduce porosity, corrosion, and stones.

Wednesday morning brought some highly technical papers. Chemical testing in micro-fashion was described for a number of minor constituents. For laboratories where spectrograms cannot be made, these methods should be quick and accurate, and their publication should make interesting reading. Testing without destruction of the specimen also sounded like a real advance. . . . No one is apprehensive about glasses coming apart between atoms, but the physical chemists present learned about the energy with which the silicon and other ions in glass hold to their oxygen.

Dolomite vs. calcite was not the title, but the idea was that the glass is changed, sometimes for the better and sometimes not, when magnesia substitutes for lime. Just as in certain pre-war contests, one has to see the curves before forming judgments, as also in many of the other research reports.

Mineralogically, nickel oxide for magnesia seems to be as natural a substitution as margarin for butter. In glass, the color is something else, and a little goes a long way . . . When attempts are made to get glass homogeneous by making it hotter, a little heat is good, but more heat is not proportionally better. The work was done without convection or contact with refractories. In practice, both these condtions are present. Interpretation is not easy.

Fine-structure had its innings, this time to the retirement of the classical theory of acid-base reactions in glasses without a hit. Brönsted went down, swinging. Lewis scored with a four-bagger—excuse it, please, we mean a co-ordination number of four. That seems to be the way aluminum gets in for silicon and leaves such a good place for calcium: aluminum takes on four oxygens without valence enough to swing the deal.

In the afternoon, the optical glass people drew a large crowd, while the plant men talked about oil consumption and control of combustion. The debates were lively, but the number of men participating was not large enough, in view of the generous attendance. This "round table" was the best pow-pow that the Division has had in some years. These things can easily become a habit again, and add greatly to the value of the annual and summer meetings for the plant men.

A survey of the titles in the optical-glass program shows that most of the important problems in this branch of the industry were expertly covered. The speakers were leading technologists, representing the principal producers.

Following are extended summaries of the majority of the papers.

Glass in the Electronics Industry. *By H. C. Steiner, Tube Division, General Electric Company.*

Electronic tube design is concerned with properties of glass which are of little importance in other fields. In particular, the glass must be of such a composition that it may be sealed to metallic leads and parts. The seal must be vacuum-tight. The expansion of the glass and metal must be closely matched or with dissimilar characteristics, the design must limit the glass stresses to safe values. At the operating temperature, the glass must have sufficient resistance to prevent electrolysis.

The paper reviewed some of these special characteristics and discussed the current use of glass in the electronics industry.

The Effect of Fluorine and Phosphorus Pentoxide on the Properties of Soda-Dolomite Lime-Silica Glass. *By Owens-Illinois Research Laboratory: Owens-Illinois Glass Company.*

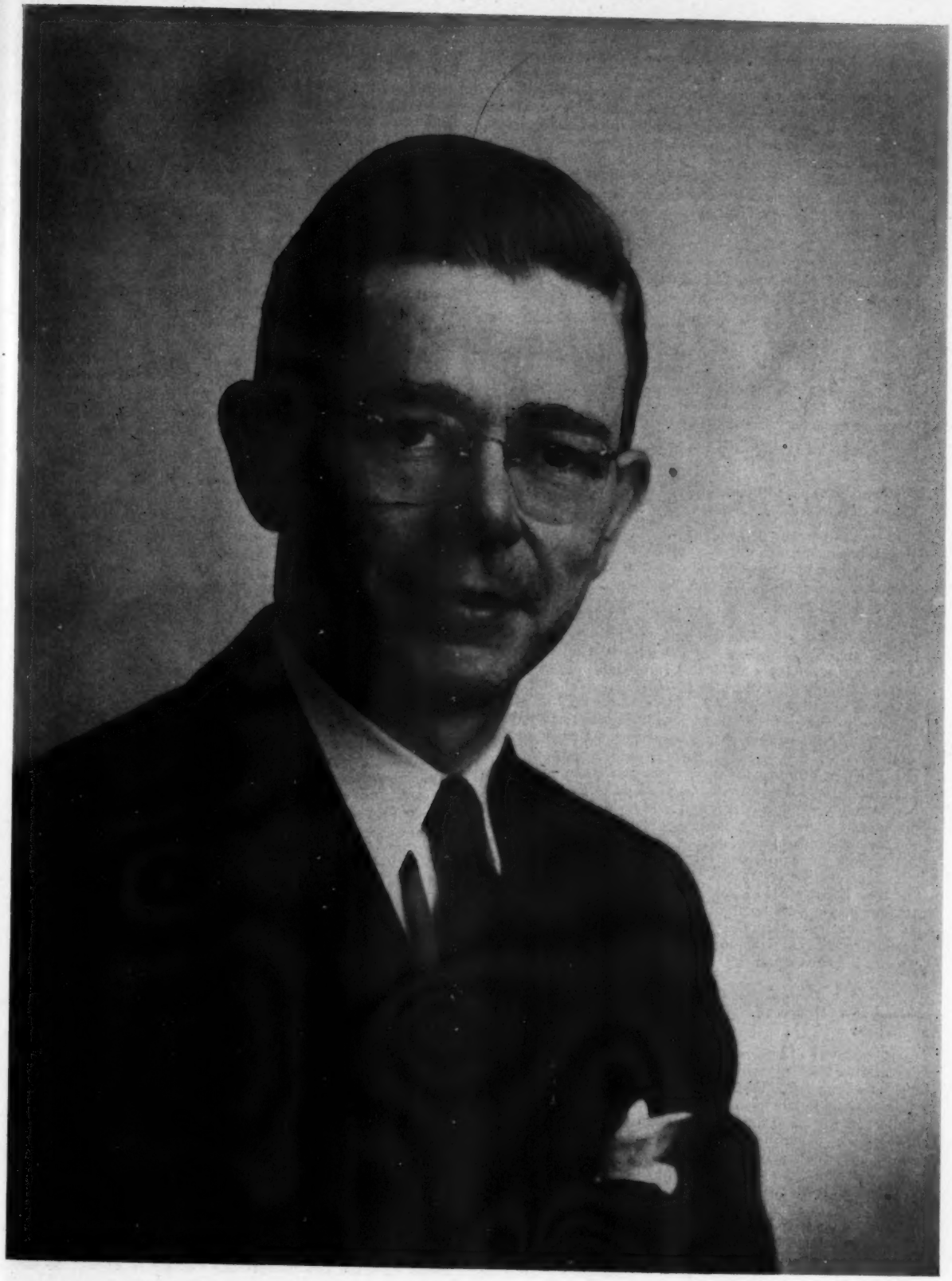
In the latter part of 1941, regular deliveries of dense soda ash to the large consumers of the material were disturbed. This situation led to an investigation of glass compositions and materials that could replace the prevailing formulations and extend to the limit the available supply of soda ash.

As the use of lithia or boric anhyride were ruled out by economic considerations, only fluorides remained as materials that might have good possibilities. In addition, since slags from phosphate operations contain not only fluorine, alumina, silica, lime, and alkali, but also a significant quantity of phosphorus pentoxide, an investigation of this constituent was also made.

The glasses were prepared from ottawa sand, burned dolomite, Solvay soda ash, technical sodium phosphate, and sodium fluoride. Approximately 4½ pounds of each glass was melted in a large covered platinum crucible in a gas-fired furnace. The glasses were stirred several times during the initial melting period and were poured, crushed, and remelted with additional stirring. The total time of melting and remelting was approximately twenty hours at 2600° F.

The following properties of the glass were then determined: 1—density, 2—liquidus temperature, 3—coefficient of expansion, 4—deformation temperature, 5—viscosity (a) fiber softening point and (b) high temperature viscosity, 6—resistance to dilute acid, and 7—resistance to distilled water. The methods of determination were exactly the same as those used in work previously reported.

From the data obtained it was concluded that: 1—Fluorine is very effective in reducing the viscosity of a glass and it is quite probable that it will increase the working range. 2—Fluorine will rapidly increase the liquidus temperature in



K. C. Lynn

the base glasses investigated. The quantity used to replace soda must therefore be limited. 3—Fluorine in the range used in these experiments does not decrease the chemical resistance. 4—Fluorine compounds are probably vaporized above the annealing temperature of a glass. 5—Phosphorus pentoxide has but little effect on the viscosity characteristics of the base glass used in this work when it replaces silica. 6—Phosphorus pentoxide does not affect the resistance properties in the range investigated when it replaces either CaO MgO or SiO_2. 7—The tendency of glasses to become opalescent in the working range when phosphorus pentoxide is present suggests that the element is not desirable in soda-lime glasses.

Properties of Some Vycor-Brand Glasses. *By M. E. Nordberg, Corning Glass Works.*

A brief resume of the process for producing high silica (Vycor-brand glasses) glasses from lower silica glasses by leaching processes was given and the physical and chemical properties of such glasses were discussed.

Some porous properties of the intermediate leached glass were given. Also, mention was made of a multiform glass prepared by powdering a high silica glass casting into the desired shape, and refiring.

Surface Tension and Persistance of Cords in Glass. *By M. A. Knight, Preston Laboratories.*

In several recent papers and discussions on the problem of the homogenizing of cordy glass, considerable emphasis has been laid on the influence of surface-tension and its influence on cord formation and persistence. One viewpoint is that the shape of immersed cords is governed by surface-tension differences between the cord and matrix glass. This view appears to be in conflict with the physics involved. A critical analysis of the subject indicates that interfacial tension is only one of several factors which influence the spreading and sinking of surface cords. Changes in chemical compositions of glasses obviously cause variations in all of their physical properties. This must be considered when the relation of surface tensions to any experimental effect is being studied.

In the case of immersed cords there appears to be no sound physical basis for attributing any shape other than that of a sphere to the influence of interfacial tensions alone. Lengthening and flattening in immersed cords is caused by the thermal and mechanical mixing of the viscous liquids and not by any surface-tension relationship. Diffusion rates are a measure of the net rate of solution of cord glass, whether the cord is immersed or floating. The importance of surface-tension in the persistence of cords in glass, however, should not be over-emphasized. Further studies may show that various other physical properties of molten glasses have greater influences than has surface-tension.

Glasshouse Stones. *By W. L. Fabianic, Owens-Illinois Glass Company.*

The subject of stones in glass still remains one of prime importance to the glass manufacturer. This is based upon the economic truth that if the annual loss of ware caused from stones in the glass can be decreased it represents a dollars and cents saving with no additional cost or overhead. The present paper discusses the various types of stones found under operating conditions in soda-lime bottle glass furnaces. The possible source of each type of stone is considered along with general methods for its identification and elimination. In addition, auxiliary aids which help in the examination of stones are described.

In brief, the types, source and cure for the stones encountered in practice are as follows: 1—Cullet stones. Refractory contaminated cullet is a prolific source of stones and can be eliminated by proper selection or forking of the cullet. Foreign cullet may contain particles of cinders, brick, concrete and metals of various kinds. Lehr cullet may cause stones if the rejected ware was running with large stones. Decorated ware, when used as cullet, may cause metallic blobs or splotches on the ware. When a siege of stones occurs it is well to first examine a large sample of the cullet.

2—Refractory stones. The elimination of stones of refractory origin is in each case a special problem all by itself and general recommendations are of little aid. Slag streams may be chilled by the application of wind. Stones from the metal lines can be decreased by maintaining a constant glass level, uniform temperature and flame length in the furnace. Refiner stones may be due to a local flame impingement or excessive refiner temperatures. Refractory stones may be decreased by raising the temperature slightly. This is based on the fact that such an increase in temperature does not loosen new stones to a greater degree than it dissolves the old ones. The various types of refractory stones are, nepheline, clay, mullite, corundum, silica and zirconia.

3—Batch stones. In general the best way to keep out batch stones is to use fine enough grain size of raw materials. They should go into solution under conditions imposed by the maximum rate of pull intended for the furnace. The raw materials should be free of material of a refractory nature. The usual batch stones are sand grains, andalusite grains, feldspar lumps, lime lumps and heavy minerals from the sand.

4—Devitrification stones. Improper liquidus point which is influenced by temperature gradient, batch inhomogeneities, incorrect glass composition, viscosity of the glass and rate of cooling, reheating of the glass, surface volatilization, incorrect furnace design and other various causes will all contribute to the formation of devitrification stones. The elimination of a siege of devitrification stones in reality boils itself down to each case becoming a special problem all by itself. This naturally assumes that the composition and viscosity of the glass in question are such that the liquidus point is within the working range of the operating conditions. If they appear in flint glass a temperature gradient of the complete furnace should be taken. Knowing the liquidus temperature one can judge whether any part of the furnace is cool enough for devitrification to occur. If the trouble occurs in colored glass, the temperature check should be made and the load checked. If a change in load is made it often moves out stagnant areas of devitrified glass. Shutdowns, water patches and batch errors also may cause devitrification stones. Quartz, tridymite, cristobalite, wollastonite, pseudo-wollastonite, diopside and devitrite are the usual devitrification stones.

5—Miscellaneous stones. These include sulphate stones due to saltcake or sulphur in the fuel, metal stones due to iron and other metals and blisters and coloring material.

Cords. *By L. G. Ghering, Preston Laboratories.*

Cords are defined as streaks, laminations, filaments, or local irregularities in the glass whose physical properties (such as viscosity, coefficient of thermal expansion, density and refractive index) differ from the bulk or matrix glass. Ridges and grooves that are formed mechanically but which sometimes have the same appearance as cords are excluded in this definition.

While it is true that temperature history influences the various physical properties of glass, these effects occur only with respect to temperatures in the annealing range. At furnace temperature it does not take long for the glass to reach an equilibrium state, molecularly speaking. In practice, these cords are associated with composition differences rather than with thermal differences. There is ample opportunity for composition differences to exist: the batch may not be completely mixed; there may be segregation in the melt with the formation of silica scum; refractory contamination is possible; and greater loss of soda or some other ingredient by vaporization may occur in one portion of the pot or furnace.

Silica or alumina increase the viscosity and cords rich in either of these two constituents are apt to appear as thick streaks or lumps. High silica may be due to unmixed batch or silica scum. If the cord is high in alumina or both alumina and silica it probably is caused by refractory corrosion.

Differences in expansitivity due to composition differences give rise to strain which can be detected by polariscope

methods. If the composition change is known the difference in expansion may be calculated mathematically. If it is not known it cannot be predicted from the polariscopic stress. However, high tension stress is usually due to high soda, and low lime, silica or alumina. Conversely, a compression stress cord is usually due to high silica or alumina or both and probably comes from refractories or silica scum.

Composition differences greatly affect the density and the determination of density differences by laboratory techniques is a valuable aid in diagnosing cord troubles. By the use of the centrifuge technique the density differences or spread can be determined and the separated fractions can be analyzed chemically for their actual composition.

Some types of cords lower the mechanical strength of the glass while others do not. Glass breaks only because of tension stress at the surface. Fractures always originate on a surface and whenever the tension stress at a surface reaches a value of about 3,000 to 6,000 psi on commercial glassware, a fracture may start. A tension cord on the outside surface of the glass therefore lowers the mechanical strength of the glass but the same cord buried in the wall is not so dangerous. Compression cords have no effect except in so far as they produce induced tension. Location and type of cord are therefore of prime importance as far as mechanical strength is concerned.

Decolorizing Pot Glass. *By S. R. Scholes, New York State College of Ceramics.*

The presence of iron in the melt causes the glass to have a green tinge unless some means are taken to improve the color. Decolorizing may be accomplished in two ways, chemical and physical decolorizing. Chemically, the color power of iron may be weakened a great deal by converting the iron into the more highly oxidized or ferric condition. Physically, decolorizing is a masking process in which the green or yellow green color is concealed by the presence of some substance or substances that would, by themselves, produce a complementary purple or violet color. In actual practice both methods are usually used together.

The problem in chemical decolorizing is to find a means of maintaining an oxidizing condition in the melt. Arensic pentoxide seems to be the most reliable reagent for this purpose. It enters the batch as arsenic trioxide, takes on added oxygen from the niter, and remains as a powerful stabilizing chemical. Cerium has been proposed, and some reports indicate that it has some effect, as a carrier of oxygen. Antimony oxide, a close relative of arsenic, should behave similarly. However, antimony trioxide takes on more oxygen all too eagerly, and holds it too firmly as it becomes tetraoxide and perhaps pentoxide. Instead of acting as an oxidizer for iron, it may even have the opposite effect. Manganese dioxide serves both as a physical and as a chemical decolorizer. Cobalt acts as a physical decolorizer, its blue color covering up the remaining trace of yellow in the glass. Neodymium oxide (used as neodymium oxalate) has an absorption quite complementary to that of iron, and it is an effective decolorizer. Its high cost is an objection. It sometimes contains as an impurty, praseodymium, which has a green ion, offsetting the work of neodymium.

In summarizing it was shown that the conditions that produce a well decolorized glass are: 1—purity of raw materials; 2—the presence of oxidizers; and 3—proper amounts of complementary colorants.

Conditions operating against good color are: 1—iron, in the raw materials or as "tramp" iron; 2 — carbonaceous material in batches or cullet; 3—high temperature; and 4—slow melting or long standing in the pot.

Qualitative Spot Tests for Minor Constituents in Glass. *By Samuel Zerfoss and R. L. Hess, Department of Ceramics, Pennsylvania State College.*

Qualitative microanalysis can be used as a routine tool in the glass plant or control laboratory to identify many of the common and special chemical constituents of glass. While the precision of the microtechnique cannot compare with that of the chemist on the spectrographer when a high precision is required, its speed and economy make it a ready routine substitute.

Qualitative micro-analysis deals with amounts of material of the order of 1 gamma (10^{-6} grams) in a concentration range of 1-100,000. The methods of analysis are based either on the formation of a colored precipitate, complex or solution, or on the precipitation of a characteristic crystal or crystal aggregate which can be identified by the usual crystallographic or petrographic technique. The latter method is not well suited for routine work. The development of color (spot-tests) is the technique commonly used.

This method, in brief, consists of dissolving from 1-10 mg. of the finely powdered glass with HF, followed by volatilization of the residual HF and decomposition of the insoluble fluorides. Interfering elements are then separated. The reagent is then added either as a soiution in water or in an organic solvent. In some cases it may be added as a powder or through the use of a reagent paper. The tests can be carried out in spot plates, either black, white or transparent, or on filter paper, as the test may demand. It has been found advisable in all cases to check the color obtained against a known standard. For this purpose the authors have prepared a series of simple glasses containing a third element, present in amounts up to 2 per cent.

Recommendations for test reagent and procedure for calcia, lead, barium, phosphate, borate, titanium, alumina, zinc, magnesia, and potassium were given. These recommendations included: 1—application, 2—reagent, 3—separation, 4—color of test, and 5—interferences. The following method will illustrate the procedure:

Element—Mg (in presence of NaOH)
Application—On spot plate
Reagent—Titan yellow in water solution
Separation—Na_2O_2—Na_2CO_3 followed by $(NH_4)_2S$
Color or test—red to orange—limit of detection 1.5 gamma
Interferences—None if separations are made. None in ordinary glass samples.

Energy Additivity in Glasses. *By Maurice L. Huggins and Kuan-Han Sun, Eastman Kodak Company.*

Many of the properties of a glass can be related to (1) its energy or stability—a function of composition and temperature—or to (2) the magnitudes of the energy humps resisting changes in the relative positions of the component atoms. This discussion concerns the first of these.

The energies of formation (Σ_i) from the gaseous ions, for about 50 simple oxides and approximately the same number of complex oxides have been computed. The Σ_i values, so obtained, are found to be approximately additive. Energy constants, Σm, for each component were then derived. If the coordination number of the m atoms in a given compound or glass is known, the Σm value can be divided by that coordination number to obtain what might be called a "contact energy"—an energy magnitude associated with a single metal-oxygen contact. Contact energies are additive and transferable from compound to compound (or glass), provided the coordination numbers do not change.

Effect of Substituting MgO for CaO on Certain Physical and Chemical Properties of Typical Soda-Lime Glasses. *By General Research Laboratory, Owens-Illinois Glass Company.*

Using the same technique which has been described in previous papers of this series, a series of glasses in which MgO replaced CaO were prepared and their liquidus temperatures, viscosities, fiber softening points, and their resistance to dilute acid and to distilled water were measured.

Two base glasses were used. The first contained 16 per cent sodium oxide, 10 per cent calcium oxide and 74 per cent silica. The second contained 14 per cent sodium oxide, 12 per cent calcium oxide and 74 per cent silica. MgO was substituted for CaO in steps of 2 per cent by weight in both of these base glasses.

In the 10 per cent calcium oxide glass the substitution of MgO for CaO caused a continual decrease in the liquidus

temperature from about 1840° F to 1640° F until a content of 6.5 per cent of MgO was reached. At this point the primary phase changes from tridymite to diopside. The liquidus temperature then increases rather slowly until an MgO content of approximately 9 per cent is reached. Further substitution of MgO increases the liquidus considerably, the primary phase changing to a compound which has not been identified.

In the 12 per cent CaO glass, substitution of MgO for CaO brings about a reduction in the liquidus temperature for the substitution of the first 4½ per cent of MgO so substituted. The lowering is from 1960° to 1790° F. At this MgO content the primary phase shifts from trodymite to diopside. The liquidus temperature increases gradually to 1920° F at an MgO content of 9.5 per cent. At this composition the phase again changes to the unidentified phase previously mentioned, the liquidus temperature rapidly increasing to 2090° F at 12 per cent MgO.

In both the 10 per cent and the 12 per cent CaO glasses the effect of substituting MgO for CaO on the viscosity is to cause a linear increase in the viscosity at high temperature (log n = 3) and to cause no change in the viscosity at low temperatures (log n = 7) until the ratio of MgO to CaO is equivalent to that in dolomite lime is reached. Beyond this ratio the viscosity at low temperatures (log n = 7) linearly increases.

Substitution of MgO for CaO causes a considerable increase in the durability of both base glasses when dilute acid is the attacking medium. When water is the attacking medium, substitution of MgO causes a decrease in the durability of both glasses up to a point where about 6 per cent MgO has been substituted for CaO. Beyond this MgO content, further substitution increases the resistance to distilled water.

The Effect of Temperature on Homogenizing Rate of Soda-Lime-Silica Glasses. *By R. L. Tiede and F. V. Tooley, Owens-Corning Fiberglas Corporation.*

In previous work the authors investigated the homogenizing rate of soda-lime-silica glasses under conditions of minimum convection mixing and in the absence of refractory materials. The present investigation is a continuation of this work and is concerned with the change of degree of homogeneity with respect to temperature. The method and apparatus, and experimental procedure employed, were the same as previously used. The glasses were prepared at temperatures ranging from 1232° to 1454° C., using a four hour melting period. Density spread determinations were then made.

It was found that there was a sharp drop in density spread in the range 1232° to 1288° C, a minimum at about 1325° C. and a slowly increasing density spread at temperatures about 1325° C. The portion of glass responsible for the major part of the density spread was found to be concentrated in the top half of the glass at both 1232° C and 1454° C. At the higher temperature the improvement in the homogeneity of the bottom layer is more marked than that observed in the top layer as compared with the results obtained on the lower temperature melt. The density spread of the glass in the bottom layer in the case of the high temperature melt was in the range of that observed for commercial soda-lime-silica glass of good quality.

Loss in weight of the glass due to volatilization was found to be negligible at 1232° C, but amounted to about 0.15 per cent in four hours at 1454° C. A possible explanation for the observed increase in density spread with increasing temperature above 1325° C is the change in composition of the glass due to volatilization.

Moderate mixing achieved by repeated cracking and remelting of the glass and by melting in a rotating tilted crucible has a marked effect in lowering the density spread.

The data afforded by these experiments lend further emphasis to the view that convection currents in commercial tank operation are highly significant in improving the homogeneity of a soda-lime-silica glass.

Light Absorption of Iron in Various Base Glasses. *By W. A. Weyl, State College, Pa.*

Iron enters a glass chiefly as an impurity of the raw materials, as tramp iron, and to a minor extent through the refractory and the furnace atmosphere. The color of iron depends on its state of oxidation as well as on the composition of the glass. Under oxidizing conditions trivalent iron is formed chiefly; under reducing conditions, divalent iron. Even under the strongest reducing condition it is not possible to obtain the total iron in the form of the colorless ferrous ions because ferrous silicate exists only in the crystalline state and decomposes partly into metallic iron and ferric silicate on fusion. That is the reason why all silicate glasses melted under reducing conditions are colored, but some phosphate glasses can be obtained colorless.

The ferric ions can play a dual role, that of a network former and that of a network modifier. In its role as network former it replaces silica and gives rise to intensive brown color. In its role as network modifier it is very weakly colored (pink). Only in phosphate glasses can all the ions be obtained in the modifying position. The amount of ferric ions present as network former determines the color. As a rule, glasses high in alkali, lead oxide, barium oxide, and titanium dioxide enhance this position. Samples were shown of different base glasses containing 1 per cent iron. Besides the ordinary green iron color, one glass was blue due to the presence of ferrous-ferric oxide, others deep brown due to trivalent iron in the network forming position and two were colorless because phosphates were used as a base.

The decolorizing effect of fluorides was explained on the basis of coordination. The fluorine ions having the same size as oxygen ions have only one negative charge as compared with the two of oxygen. The decrease in charge decreases the mutual repulsion and consequently it is easier to accommodate six fluorine ions around one ferric ion than six oxygens.

Chemical Reactions of the Surface of Optical Glass. *By H. C. Hafner and N. J. Kreidl, Bausch and Lomb Optical Company.*

In discussing the surface treatment of optical glass four main types of behavior of the glass surface were distinguished: (a) adsorption, (b) base exchange, (c) solution, (d) formation of new compounds.

The mechanisms involved in coating (a), acid leaching (b), acid polishing, etching, alkali cleaning (c) and HF vapor filming (d) were correlated to these principles of behavior.

Acid attack is treated as a variation of base exchange. At elevated temperatures and in an electrical field, Na^+ may be exchanged for Cu^+, Ag^+, Li^+ and other ions. In acidic solutions and diluted acids, the exchange reactions may take place at lower temperatures. In this case, Na^+ is exchanged for H^+. A silica film remains after dehydration.

The optical industry uses the time required in 1 per cent HNO_3 to form such a film of ¼ wave length as a yardstick to express rate of chemical attack. The usual classification discriminates five classes of resistivity: (1) more than 100 h; (2) 10-100 h; (3) 1-10 h; (4) .1-1 h; (5) less than .1 h. The film thickness is recognized by the purple interference color in white illumination. For experimental purposes two other scales were established:

a) for the discrimination of very resistive glasses of class 1: .1 h, 1 h, 10 h, 100 h, 100 h in 50 per cent HCl at 90° C.

b) for highly reactive glasses of class 5: .1 h, 1 h, 10 h, 100 h, 100 h in 1 per cent sodium phosphate (commercial calgon) solution or in boric acid at room temperature. These tests are applied if the regular test causes no film formation because of complete dissolution.

The network forming constituents of a crown glass were interchanged or replaced by modifying constituents. It was found in which way filming time decreases as SiO_2 is replaced by Na_2O, B_2O_3, Al_2O_3, and Na_2O by K_2O. The lower

(*Continued on page* 231)

"The Trail Blazers" by Robert W. Knauft
First Prize, Pictorial

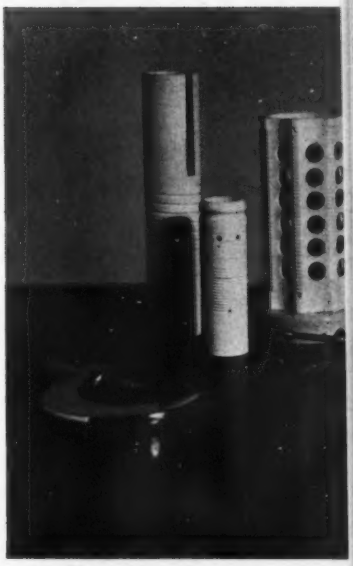
"Peace in Green Valley" by J. Earl Frazie
Honorable Mention, Pictorial

Ceramic Camera Club

"La Senorita" by V. H. Remington
The Frazier Award. First Prize, Portrait

Prize Winners 1944

"Hound Pup" by George A. Mays
Honorable Mention, Portrait



"Steatite Coil Cores"
by Rolland Roup
First Prize, Industrial

"Sunbeams and I Beams" by H. M. Kraner
Honorable Mention, Industrial

THE NEW TEXAS PLANT OF OWENS-ILLINOIS

Waco plant now producing 9,000,000 containers a month with plans in process for doubling capacity.

The southwestern plant of Owens-Illinois Glass Company at Waco, Texas, new from the ground up and modern in every respect, is now in its third month of operation.

From its two Owens suction machines and its three feeder type machines it is producing containers at the rate of nine million a month and plans are now under way to double the plant capacity as soon as federal government approval for the necessary material has been obtained.

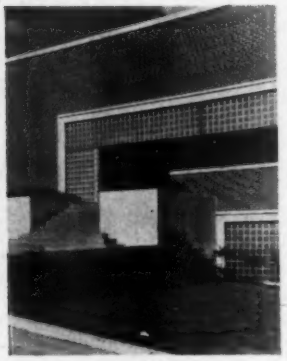


Fig. 1. The main entrance.

A staff of 300 people recruited in large part from the Waco district, is manning this new Texas industrial enterprise. Some of the key people in the various departments were sent into the plant from other Owens-Illinois factories in various parts of the country.

The plant is located on a 55 acre tract south of Waco and is served by the Missouri-Kansas-Texas Railroad and a fine system of highways so that shipments can be made with excellent facilities by both railroad and truck.

The plant presents an imposing appearance from the main highway which it faces. The buildings along the highway house the power house, purchasing and stores, shops, main offices and the warehouse and are built of brick and glass block. A spacious lawn surrounds these buildings and the entire property is enclosed by a high wire mesh fence.

At the main gate on the highway there is a smaller white building of frame construction which serves as a reception center and provides offices for the personnel division including the plant nurses and physician.

A concrete drive branches off in two directions from the main gate inside the grounds. One part of the drive serves the purchasing and stores department and the other leads to a wider concrete ramp in front of the warehouse loading dock.

Back of the buildings along the road are located the operating departments of the plant. The batch house is to the north of the main buildings in a separate structure which is served by a railroad spur track.

Batch material is brought into the grounds in hopper cars and dumped by gravity into pits below the track. From these pits it is elevated to the top of the batch house in bucket conveyors and there dumped into the various tanks provided for storage.

Ingredients are measured by electrically controlled weighing devices, mixed and dumped into batch cars which carry the raw material to the melting furnaces on a monorail track.

The feed from the batch cars to the furnace is by gravity and worm gear. Natural gas from the vast reservoirs of Texas is used as fuel.

As is customary the Owens machines suck their part

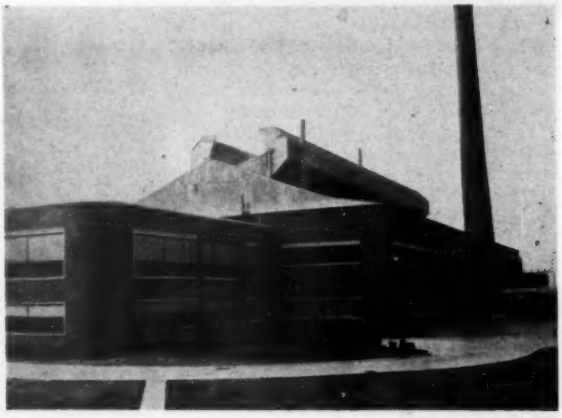


Fig. 2. A view of the north side of the plant. The building at the left houses a machine and mold shop, on the second floor and the power house on the first floor. In the larger building at the rear are the furnace area and the forming machines.

of the glass from huge revolving pots at the working end of the furnace, while the flow machines are fed from forehearths extending from the working end of the tank.

The Waco plant has five annealing lehrs through which finished ware passes to the packing room.

These lehrs are gas fired with electrical temperature controls. In the spacious forming machine section of the plant there is a catwalk extending across the entire width of the building where visitors can observe operations in the plant with a minimum amount of interference to operators.

Incidentally, the base for the second furnace was placed in the Waco plant when the buildings were erected and thus the new furnace can be gotten under way very

Fig. 3. An exterior view of the plant looking south. The building in the foreground is the machine and mold shop and the power house. The center building houses the offices on the second floor and purchasing and stores on the first floor. The building in the background is intended for future use as a decorating department.

quickly when the federal government gives the "go ahead" sign.

The selectors at the new plant are all girls specially trained for their duties. Cartons in which they pack the finished ware come down to them on metal chutes from a mezzanine floor at the rear of the cold end of the plant. On the mezzanine another crew of girls staples boxes and assembles partitions.

The warehouse and shipping department are immediately beyond the mezzanine. At the present time a portion of the warehouse and that part of the buildings intended to house a decorating department has been leased to the United States Army for storage of war materials.

The mold and machine shops and the quality control laboratory are housed in the portion of the buildings fronting on the main highway. There is also a working portion of the quality control division in the center of the cool end of the factory proper.

Quarters for the plant manager and his office force are

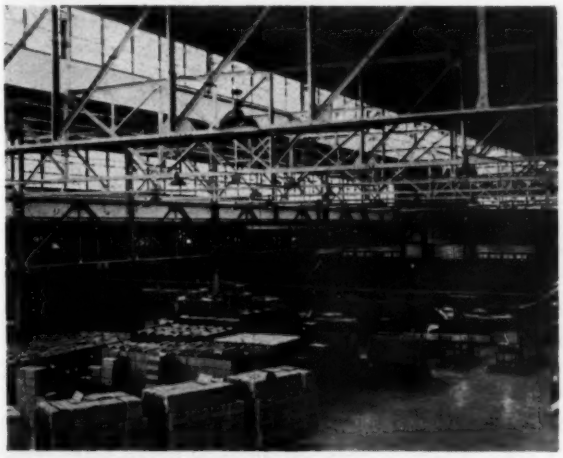


Fig. 4. An interior view of the light and airy packing room at the cool end of the manufacturing area.

modern and comfortable and the entire plant has an air of cleanliness and brightness which is second to none in the industry.

Every available facility has been provided for the comfort of the employes. There is a comfortable lounge room for the women. Fine toilet facilities and shower rooms are available for all of the workers.

Suspended baskets instead of old fashioned lockers are provided for the clothing of the workers.

Because the manufacturing operation is of a continuous nature, most of the workers eat one meal on the job. In keeping with its custom Owens-Illinois has provided a fine

Fig. 5. An interior view at the hot end of the plant. In the foreground can be seen the base for the second furnace which will soon be built. The furnace now in operation and the forming machines are in the background.

food service restaurant with the best of facilities and an experienced staff. Food will be served hot, at or near cost, and the service will be available on a 24-hour a day basis.

The first aid room in the personnel department also is staffed by trained nurses on all shifts and the doctor is in attendance every day.

George Walter, a veteran of 28 years with Owens-Illinois, is the plant manager. His assignment prior to his present position was manager of the company's warehouse at Houston.

Owens-Illinois' resident engineer on the construction job was William Milbratz of the Alton Engineering Department and the entire job was supervised for the company by Richard Cosh, chief engineer, also of Alton.

The buildings were designed by Robert and Company of Atlanta, Ga., and the construction job was by Inge Construction Company of Dallas, Texas.

First bottles were made January 3, 1944, and formal opening ceremonies were held February 22nd, at which time three hundred of the company's customers from the southwest were shown through the plant.

Fig. 6. A quality control operator examining a coffee jar in the light of a polariscope.

Fig. 7. A close-up of two of the girl selectors at the discharging end of the lehr showing the overhead chute which supplies them with shipping cartons.

INVENTIONS AND INVENTORS

A Summary of United States Patents of Interest to the Glass Industry Issued During March

Compositions

Chas. J. Kinzie and Donald S. Hake of The Titanium Alloy Mfg. Co. have contributed to the art of opacifying vitreous enamels by describing in patent 2,343,908 a method of making white enamels by using zirconium oxide containing some adsorbed carbon dioxide. Especially effective results were reported when six per cent of such a zirconia was added to a suitable frit together with the same percentage of enameler's clay and 0.25 per cent of magnesium carbonate. When this vitreous enamel mix was applied to ground-coated iron and fired, the resulting opacity of the coating was said to exceed that of the same frit prepared with six per cent tin oxide as the opacifier. In the firing operation the coating increased considerably in thickness due to the liberation of the adsorbed carbon dioxide or to its decomposition at about 1500 degrees F. These gas bubbles contribute to the effect of opacity.

Feeding, Forming and Shaping

Fig. 1 illustrates the improvements in a revolving pot invented by Albert G. Lauck of Alton, Ill. (2,344,464

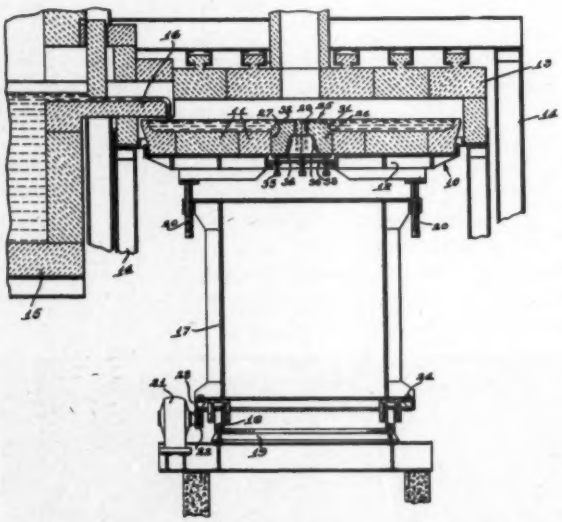


Fig. 1. 2,344,464 : Lauck. Forehearth for suction feeding in which there is a central well for drawing off surface glass which may contain stones.

assigned to Owens-Illinois Glass Co.) to contain a supply body of molten glass from which mold charges are gathered by suction and transformed into containers. The glass which is gathered by the molds of a forming machine is very largely that portion in close proximity to the surface of the supply body. Very often, and particularly with amber glass, blisters, seeds and the like, form upon the surface and too frequently find their way into the finished containers. To avoid the necessity of using skimmers and other devices which remove some surface glass which must be reheated before returning to the gathering area, Lauck provides an overflow opening in the center of the pot. As shown at 28 in Fig. 1 this drains the surface glass from the supply body and permits it to flow by gravity through a central or axial discharge passageway, and then into a cullet buggy underneath. One provision of the patent is that the orifice 25 be readily removable so that its height may be adjusted for regulating the flow of glass from the pot.

Miscellaneous Processes

Patent 2,344,081, vested in the Alien Property Custodian, has issued to Andre Claude of Paris, France, for a process for causing luminescent substances to adhere to glass surfaces. The glass is coated with a suspension of such substances in a volatilizable organic liquid, together with boric, phosphoric, arsenic or antimonic acids, and then it is fired to burn out and volatilize the liquid.

Carl B. Williams Jr. of Toledo received and assigned to Libbey-Owens Ford Glass Co. his patent 2,345,166 for a cutting machine for cutting curved glass articles from laminated glass sheets. The machine provides means by which a curved or bent sheet of laminated safety glass may be simultaneously cut along two parallel oppositely disposed lines on opposite sides of the composite sheet, so that both sheets can be cut in a single operation.

Frank L. Jones of Bausch & Lomb Optical Co. was granted patent 2,344,250 for a new film coating for glass to improve light transmission. The invention is related to the known process in which a glass article is immersed in a leaching solution which takes out some of the alkalies and leaves a surface film of silica, Jones instead uses a bath or leaching solution which not only removes alkali but actually replaces it with another oxide. The process is particularly intended for crown glasses. The replacing material is a compound of silver. Typically silver nitrate is melted and its temperature raised to 300 degrees C., and the glass article is kept immersed for from one to 100 minutes. Subsequently the ware is leached with acid to remove any acid-soluble oxides. Hydrochloric acid is suitable for this purpose.

Patent 2,345,278 granted to A. J. Monack of New York (R.C.A.) describes a technique for sealing glass to iron.

Many difficulties are met with when attempts are made to extend to the field of glass containers, especially of the narrow neck variety, the great strides which have been made in tempering flat glass. These troubles are due to the disproportionate thicknesses of different parts of the bottle and to the limitations standing in the way of supplying and removing the chilling gases used in tempering. Tempering art has of course been successful with lenses of nonuniform thickness, but this has been accomplished by concentrating the chilling effect at the thicker portions, in a way which has not been feasible

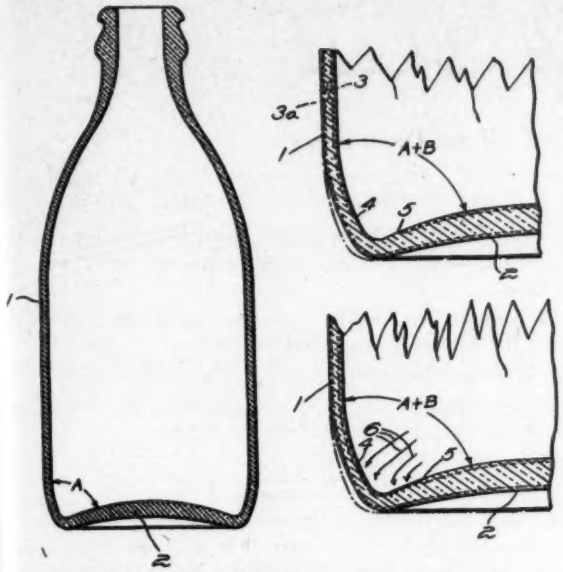


Fig. 2. 2,344,630 : Mylchreest. Views illustrative of various tempering stresses.

within narrow necked containers. In such containers the ratio of the thickness of the sidewalls to the bottom is seldom less than 1 to 2 and may be considerably higher. When cold gases are admitted to such ware the bending force that may be set up by reason of the difference in time at which the sides and bottom pass through the strain point usually results in tension areas in internal surface layers near the bottom corners. This constitutes a serious defect in the article. After studying this problem George D. Mylchreest of Hartford, Conn. (Hartford-Empire Co.) has suggested certain solutions in patent 2,344,630.

His ideas are best illustrated by reference to Fig. 2. At the left is the vertical section of a bottle before tempering. The sidewall is considerably thinner than the bottom, and these two portions join at an angle of approximately 90 degrees at A.

The upper right hand view illustrates the change in shape which results from chilling the hot walls so that these thinner sections become set earlier than the thicker bottom. In the case illustrated the rate of chilling of the thicker bottom is proportionately slower than that of chilling the sidewalls. The angle between the walls and bottom is now greater and is indicated by A+B, this increase in the interior angle being caused by the bending in of the sidewalls by the shrinkage of the bottom after the sidewalls had set. The dotted line 3 indicates the position of the line of zero stress which in the sidewalls separates the inside surface layer which is in compression from the interior layer which is in tension. It is noted that the line 3 approaches and runs out of the inner surface of the bottle at the point 4 and appears again in the bottom at the point 5, indicating the undesirable condition of surface layers in tension between points 4 and 5. This condition which the inventor proposes to eliminate is attributed by him to the increase of the internal angle and the resulting uncompensated bending stress in the surface area 4-5 as the thicker bottom becomies set after the thinner sidewalls have been cooled to a set condition.

Mylchreest proposes several procedures which eliminate the tension areas on the glass surfaces. He makes no effort to cool the ware at rates proportionate to its varying thickness, but applies a concentrated chilling effect at the inner angle of the bottle where the sidewalls and bottom meet, and by this means counteracts the tendency for tension to develop at the surface along that critical line. In the lower right hand view of Fig. 2 this result is indicated by the zero stress line which is entirely within the ware.

Sheet and Plate Glass

Another contribution to the art of tempering glass is patent 2,343,490 assigned to Libbey-Owens-Ford Glass Co. by Gerald White of Toledo. This consists of a frame for supporting a considerable number of small pieces of glass while being tempered. As shown in Fig. 3 the frame is built from tubular metal sections and is carried from an overhead monorail. The horizontal members 45 are adjustable in height so ware of various sizes can be handled. The glass plates are supported on blocks or pins 68 which may be inserted at any location on the horizontal tubes 45 since these are drilled at close intervals to accomodate inserted pins. In addition to this bottom support the horizontal tubes above the ware also staples through holes in these bars which loosely touch contribute support. This is accomplished by dropping both sides of each plate. White points out that in addition to the obvious adjustability of the apparatus, other

(*Continued on page* 236)

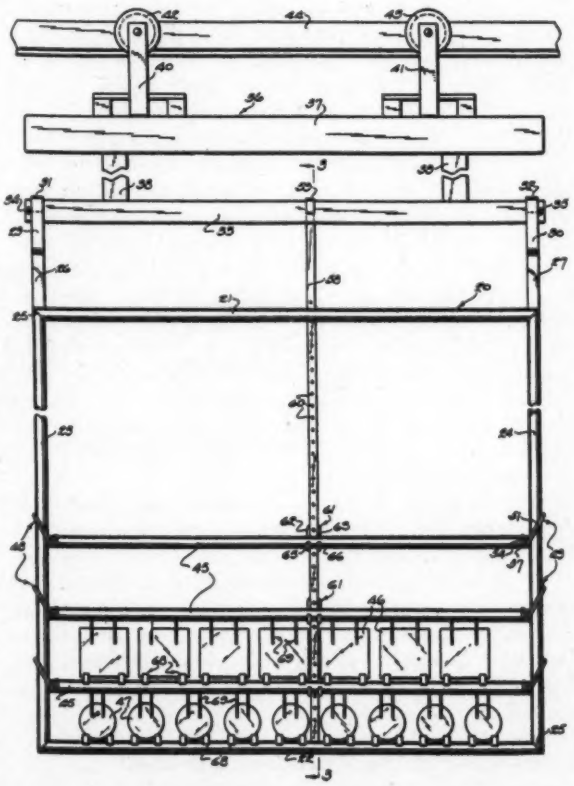


Fig. 3. 2,343,490 : White. Frame which holds small glass plates and discs during tempering.

Research Digest

Practical Interpretations of Glass Technology

Factors Affecting the Degree of Homogeneity of Glass

The degree of homogeneity obtained in a glass is a function of the past history of its preparation and the major factors involved include: 1 — temperature, 2 — time, 3 — batch formulation or combination of raw materials employed, 4 — degree of uniformity of mixing, 5 — segregating tendency in conveying and melting, 6 — nature and degree of convection and mechanical stirring, and 7 — physicochemical relations in the batch-glass-refractory system.

Tooley and Thiede, *Journal American Ceramic Society*, February, 1944, have reported on an initial investigation which was concerned with the rate at which a common soda-lime-silica glass increases in homogeneity when melting takes place in the absence of refractory and where minimum convection mixing occurs. Under these conditions, the homogenizing process is chiefly that of simple diffusion aided by no mechanical stirring, a minimum of convection stirring, and uncomplicated by the presence of foreign bodies.

The experimental procedure consisted of melting a simple soda-lime-silica glass (SiO_2 73%, Na_2O 170%, and CaO 10%) in a platinum crucible at 2250° F for 1, 2, 4, 7½, 16, 32 and 64 hours. The annealed samples, which were clear and seed free, were then crushed and the resulting powder centrifuged according to the Turnbull Ghering technique. From the density spread measurements so obtained it was concluded that: 1 — In the absence of any furnace refractory and under conditions of minimum convection mixing a soda-lime-silica glass increased in homogeneity rapidly during the first 16 hours of melting (drop of 9° C in density spread) and at a much slower rate with additional melting time (drop of 5° to 6° C in density spread from the sixteenth to the sixty-fourth hour). 2 — The portion of glass responsible for the major part of the density spread was lower in density than the parant glass corresponding to a glass higher in silica. This fraction was found to be concentrated in the top half of the melt in the case of each of the two melts on which such a determination was made, indicating the tendency for silica to concentrate at the surface during melting.

These density spread results, when compared with those reported by Turnbull on a series of commercial bottle glasses (spreads of scarcely more than 0° to about 3° C) indicate that the temperature, time and convection mixing characteristics of tank operation, in comparison with these experimental conditions, are very effective in increasing homogeneity, especially when a dehomogenizing tendency caused by the refractories is also present in the tank operation.

Raw Material Specifications (British)

Revised (1943) specifications for both limestone and sand for making colorless glass have been published in the October, 1943, issue of the *Journal of the Society of Glass Technology*. These specifications in brief are as follows:

Limestone for making colorless glass shall comply with the following requirements:

1—Moisture Content

As received by the glass manufacturer, the limestone shall not contain more than 2% moisture.

2—Grading

A—For Use in Tank Furnaces

The proportion of the material passing B.S.I. sieve No. 120 shall not be more than 25% as determined by the standard procedure given in the specification.

B—For Use in Pot Furnaces

The limestone must all pass a sieve of ⅛ inch aperture, and not more than 5% shall remain on B.S.I. sieve No. 14, when tested according to the standard procedure.

3—Chemical Composition

The chemical composition of a sample, prepared and analyzed according to the procedures outlined in the appendix of the specification, shall fulfill the following requirements: 1—The calcium content, expressed as calcium carbonate ($CaCO_3$), shall not be less than 98.5%. 2—The total iron content, expressed as ferric oxide (Fe_2O_3), shall not exceed 0.04%. 3—The carbon present other than as carbonate shall not exceed 0.1%. 4—The total non-volatile matter, including silica, insoluble in hydrochloric acid, shall not exceed 1%. 5—The other impurities—if any of the elements manganese, lead, sulphur and phosphorus be present in the limestone to the extent of more than 0.1%, their presence and amount must be declared by the vendor.

The appendix to the specification includes methods of sampling, inspection for contamination, grading of grain sizes, determination of moisture content and methods for the chemical analysis.

Sand for making colorless glasses shall comply with the following requirements:

1—Moisture Content

The sand, as received, shall not contain more than 4% of moisture.

2—Grading

The sizes of the grains constituting the sample shall lie between the following limits (B.S.I. sieve sizes):

Remaining on Sieve No. 16	Nil
Remaining on Sieve No. 25	Not more than 1%
Remaining on Sieve No. 36	Not more than 5%
Passing Sieve No. 100	Not more than 10%
Passing Sieve No. 120	Not more than 5%

3—Chemical Composition

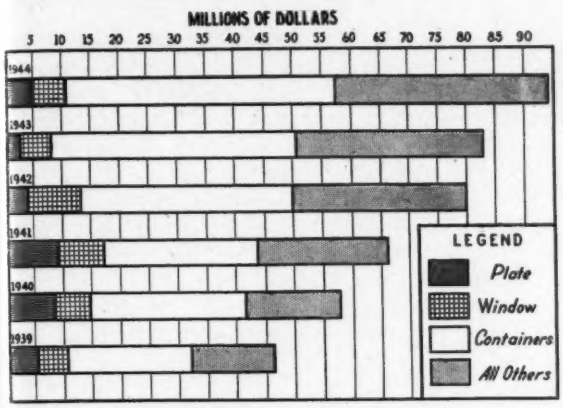
The purity required of the sand shall be fixed accord-

(*Continued on page* 226)

CURRENT STATISTICAL POSITION OF GLASS

THE GLASS INDUSTRY'S INDEX

Production: Two Months, January Through February



February activity in the glass industry, while showing minor variations in certain divisions, remained at approximately the same level as that reported for January. According to the Production Index, output during February was $47,000,000 as compared with $40,000,000 for the same month last year.

Plate glass production for March totaled 8,702,250 sq. ft., as shown by the Hughes Statistical Bureau. This was an increase of 9 per cent over February, and of 66 per cent over March, 1943.

Glass container production during March totalled 8,842,036 gross, according to the Glass Container Association of America. This enormous total represents the largest single month's production of glass containers in the history of the industry, exceeding the previous all time high of October, 1943, by 256,542 gross. March production also showed an increase of about 13 per cent over February, and about 17 per cent over March, 1943. During the first three months of 1944 glass container production amounted to 24,816,210 gross, as compared to 21,593,899 gross for the first quarter of 1943—an increase of approximately 14 per cent.

Shipments of glass containers during March increased about 10 per cent over February and about 2 per cent over March of 1943. Cumulative figures for the first quarter of 1944 show that shipments during this period were about 6 per cent higher than for these months in 1943.

Inventories on glass containers for March were 4,779,600 gross—representing an 8 per cent increase over the preceding month. However, this is about 28 per cent less than March of last year.

Automatic tumbler production for March was reported at 5,862,158 dozens, an increase of 32 per cent over March, 1943. Shipments of automatic tumblers during March amounted to 5,756,136 dozens, as compared with 5,337,543 dozens during the same month of 1943. Finished stocks on hand at the end of March were 6,989,529 dozens.

Table, kitchen and household glassware: Manufacturers' sales of machine-made table, kitchen and household glassware were reported at 2,164,026 dozens, a decrease of 54 per cent from March, 1943.

Miscellaneous glass products manufactured in February were estimated at $18,000,000, the same as reported for January.

Employment and payrolls: The number of people working in the glass industry during February totalled

GLASS CONTAINER PRODUCTION AND INVENTORY

(All Figures Are in Gross)

		Production Mar. 1944	*Stocks Mar.* 1944
Foods; Medical & Health Supplies; Chemical, Household, Industrials; Toiletries & Cosmetics	Narrow Neck	2,784,014	1,777,064
	Wide Mouth	2,908,429	1,398,750
Dairy Products		272,887	352,704
Home Canning		444,418	275,495
Beverages		665,004	349,001
Beers		879,031	135,543
Liquors		546,809	346,893
Wines		246,191	104,301
Packers Tumblers		95,253	38,849
Total		8,842,036	4,778,600

GLASS CONTAINER SHIPMENTS

(All Figures Are in Gross)

Narrow Neck Containers

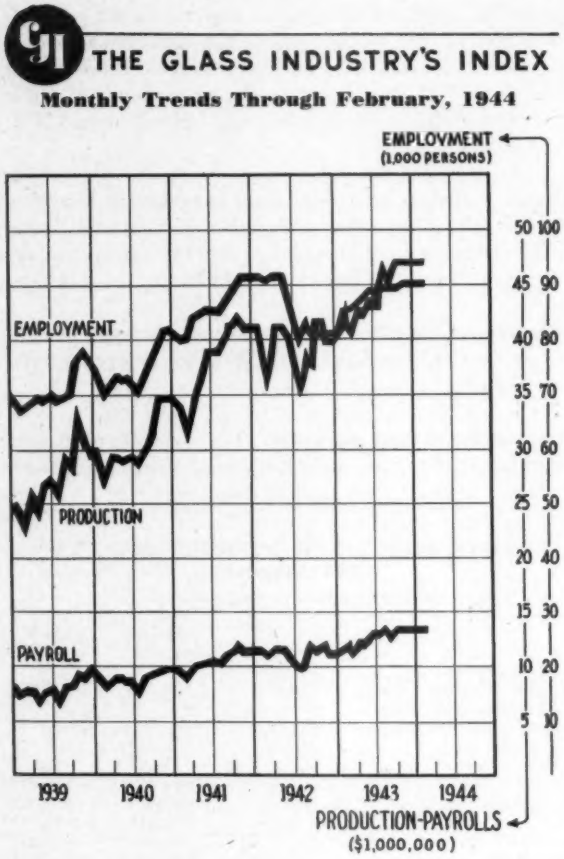
	March 1944
Foods	622,550
Medicinal & Health Supplies	946,786
Chemical, Household, Industrials	623,944
Beverages	627,609
Beers	843,978
Liquors	499,328
Wines	249,472
Toiletries & Cosmetics	444,380
Sub-Total (Narrow Neck)	4,858,047

Wide Mouth Containers

Foods	2,191,462
Dairy Products	254,727
Home Canning	383,671
Medicinal & Health Supplies	204,800
Chemical, Household, Industrials	157,341
Toiletries & Cosmetics	181,398
Packers Tumblers	93,676
Sub-Total (Wide Mouth)	3,467,075
Total Shipments	8,325,122

91,000, the same figure as reported in January. This compares with 85,000 employed during February, 1943.

Payrolls in February were estimated at $13,500,000, which is the same as that reported for January. This is a slight increase over the figure shown for February a year ago.



CONTINUED USE OF SUBSTITUTE FUEL URGED BY WPB

War Production Board officials recently announced that the use of natural gas at the normal rate in the Appalachian region will not be possible until October. Continued use of substitute fuel at the present rate is necessary to permit enough natural gas to be conserved and stored underground for withdrawal next winter.

It is hoped that the gas storage program now getting under way will have been brought to a successful conclusion by Fall, WPB said. Unless sufficient gas is stored underground this summer, industry will be faced with an unprecedented shortage of natural gas next winter.

It is understood that glass manufacturers who contemplate the use of a substitute fuel for natural gas will have the cooperation of the Glass Unit of the WPB in securing the necessary equipment for its use. The Glass Unit, headed by John R. Hostetter, will also assist glass manufacturers in the acquisition of the required fuels.

GLASS CONTAINER ASSOCIATION SETS DATES FOR SPRING MEETING

The Spring Meeting of the Glass Container Association will again be held at the Hotel Biltmore in New York. The meeting is scheduled for May 17, 18 and 19. The first day will be devoted to the Board of Directors Meeting and Committee Meetings. Membership sessions will occupy the two succeeding days.

CHANGES IN WPB CONTAINERS DIVISION INVOLVE SEVERAL GLASSMEN

Few departments in Washington have a record for personnel turnover equalling WPB's Containers Division. Last month it was not so much turnover as changeover, but there was plenty of that. One top executive moved out, another moved up, and three new specialists augmented the staff of the Glass Container and Closure Section, which is headed by Lewis F. Gayner.

Fred G. Rieman, assistant vice president of Ball Brothers, retired as assistant director. Mr. Rieman came to WPB last October on an eight months leave of absence. With one week deducted for good behavior, Mr. Rieman was allowed to depart April 21 following a farewell party given in his honor by the entire glass section. He was an exceptionally valuable find for WPB through his intimate experience with production phases of glass making in addition to his executive qualifications.

S. W. Dennis, a new member of the Glass Container and Closure Section, is the manager of the Milk Bottle Closure and Equipment Division of the Crown Cork & Seal Co. He came to WPB on March 30 and will be its Closure Specialist.

Hugh Crawford has returned to the Division after an absence of a little over a year. Mr. Crawford was at one time Pacific Coast Sales Manager for Anchor Hocking and is now associated with Ball Brothers. He will be a consultant, also in the Glass Container and Closure Section.

F. W. Britt was manager of the New York office of Foster Forbes Glass Co., until he took up his WPB duties April 24. Mr. Britt has been with Foster Forbes for approximately six years. He has a wide technical knowledge of glass, particularly container design.

NEW METHOD OF REDUCING LIGHT REFLECTIONS IN CAMERA LENSES

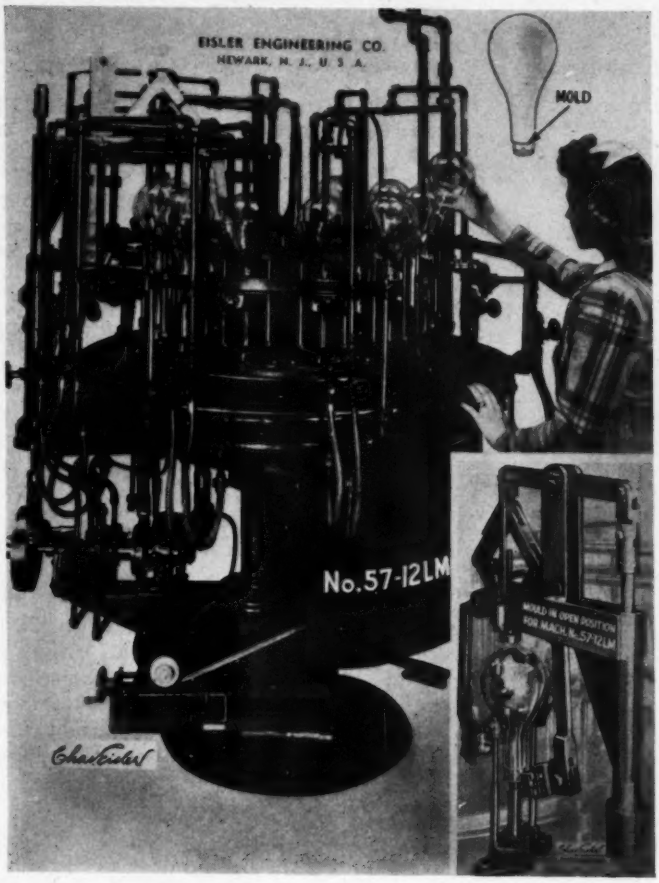
The American Optical Company recently announced that taking better pictures in either dim or bright light will be made possible for camera fans by a new method of reducing light reflections in camera lenses.

When the performances of untreated lenses and those treated by the new technique were compared it was found that the latter possessed an increased light transmission ranging from over 6 per cent for a one-lens camera to over 50 per cent for a four-lens camera. This gain in light transmission will enable a photographer to take better pictures in dim light, and in bright light will reduce undesirable light images such as "ghosts" and out-of-focus images.

This new method of treating lenses is at present being used solely for war purposes.

NEW EQUIPMENT AND SUPPLIES

EISLER SEALING MACHINE WITH MOLDING ATTACHMENT



The conventional practice of cementing the glass body of a bulb to the metallic base is not applicable for larger incandescent lamps—from approximately 300 watts and up—because of the destructive influence of the greater heat radiation on the connecting cement. A reliable method, now employed without use of cement, consists of a metallic collar with resilient prongs and four convex indentations snapping tightly into coinciding concave notches, provided in the neck of the glass bulb. Solid connection between base and bulb, impervious against heat, is then completed by screwing the threaded cylindrical part of the interposed collar into the metallic base, which now normally can be screwed into the socket.

An interesting new machine, performing automatically these technological requirements for mass production of large incandescent lamps, has been built and placed on the market by the Eisler Engineering Co., Newark, New Jersey.

This machine, pictured in Fig. 1, not only seals the stem to the bulb, but accomplishes at the same time the forming of its neck, necessary for the forementioned cementless connection. The dominant feature of this machine is the cam actuated molding attachment Fig. 2.

The operation of the machine, briefly outlined is the following: A barrel-cam mechanism provides an intermittent motion of the lamp-loaded rotating table (spider) and an endless chain-driven gear combination keeps the bulb holders continuously revolving around their own axis. Properly placed double decker burners supply sufficient heat for the necessary stem-to-bulb sealing operation. Each time when the bulb comes into the molding position, during the rest phase of the indexed spider, a pin-stop-arrangement interrupts the revolving motion of the bulb and simultaneously the tongs of the molding attachment (see Fig. 2) are put in action, forming the mold around the soft bulb neck. A cam actuated economizer admits air into the bulb during this molding operation.

Two idle bulb-holder positions in front of the operator are allocated for loading and unloading the lamps. All the operator has to do, is to take out the finished lamp and to insert new stem and bulb.

The machine, made in several sizes, is supplied with ⅓ HP motor and can also be arranged for hard glass work and illuminating gas and oxygen fire. Gas pressure is 13″ water column, air pressure 3 pounds per square inch. The production of the pictured machine is approximately 450 lamps per hour.

CATALOGUES RECEIVED

Chain Belt Company, Milwaukee, Wis., has just issued a new catalogue describing REX Z-Metal chain belts for drive and conveyor service in many industries.

Included in the booklet is an explanation of what REX Z-Metal is and illustrations of the various chain belts the company offers.

Leeds & Northrup Company, Philadelphia, Pa., has published a 23-page catalogue (N-95-163) entitled "Micromax Condensate-Purity Instruments for the Steam Plant." The catalogue describes how condensate is sampled continuously by means of a conductivity cell, and its purity indicated and recorded automatically by means of a Micromax recording instrument.

The B. F. Goodrich Company, Akron, Ohio, has issued a 12-page manual on the Rivnut—an internally threaded and counterbored tubular rivet made from one of the most corrosive-resistant practical aluminum alloys. The booklet gives all details, including sizes, description of tools and instructions for application.

Wheelco Instruments Company, Chicago, Illinois, has announced a new edition of its Wheelco Thermocouple Data Book and Catalog, Bulletin S2-4. The 36-page catalogue gives a description of products, prices and recommendations for thermocouple users, and suggests substitutes for restricted materials.

Also carried are temperature conversion tables, millivolt tables, and tables on pipe and wire sizes, decimal equivalents and wire resistances. Instructions are given on checking thermocouples and pyrometers, and on construction and thermocouples.

CATALOGUE & BULLETIN SERVICE

Current catalogs and manufacturers' service bulletins received in this department may be obtained by writing to THE GLASS INDUSTRY.

RESEARCH DIGEST . . .

(*Continued from page* 222)

ing to which of the three following classes of glassware is to be manufactured from it:

(a) Fine Optical Glass
(b) High Grade Domestic and Decorative Glassware
(c) General Colorless Glassware Including Containers

The requirements, based on material dried at 110°, shall be:

Class of Glassware	Minimum Silica (SiO_2) Content	Maximum Iron Oxide Content (as Fe_2O_3)	Maximum Titania (TiO_2) Content
(a)	99.0%	0.008%	0.03%
(b)	99.0%	0.02 %	0.05%
(c)	98.5%	0.04 %	0.10%

Other coloring oxides shall not be present in proportions such as to produce in the test glasses made from trial melts, color noticeably different from that in a similar trial melt made from a sand known to be satisfactory. Should the color be noticeably different from that expected from the iron oxide content alone, the presence of coloring oxides other than that of iron is to be suspected.

The appendix to the specification includes methods of sampling; inspection for contamination by tramp iron, heavy minerals and carbonaceous material; grading of grain sizes, determination of moisture content and methods for the chemical analysis.

It may be mentioned that these British specifications cannot be used without modification for American limestones and sands. For example: many American limestones contain appreciable amounts of magnesia and due to the lower iron content of some American sands the iron content of the limestone may be correspondingly higher. Likewise, many American sands contain less silica than 98.5% (high alumina content) and are successfully being used for colorless glass.

Determination of Density by the Flotation Method

T. C. Vaughan in the February, 1944, issue of the *Bulletin of the American Ceramic Society*, describes in detail the method and apparatus for determining by a flotation method the density or density differences of small glass samples. The method is useful for determining differences in density of samples taken from various parts of the same bottle and for identifying small pieces of glass reported to be from a given jar or bottle. The method is also used for measurements on seedy or blistery glass when only small samples of seed-free glass are available. Its use may be extended to the determination of odd minerals sometimes found in raw materials.

The method, in brief, consists of adjusting the density of a mixture of xylene and acetylene-tetrabromide so that the sample suspended in the mixture shows no appreciable vertical motion in a reasonable length of time. The density of the liquid is then determined by the method of Archimedes, using an accurately calibrated standard. Measurements are made at room temperature without the use of special equipment. No temperature correction is necessary if the standard chosen has approximately the same coefficient of expansion as the material under investigation. Measurements made at various temperatures are automatically corrected to a common temperature by using a fixed value for the density of the standard.

INVENTORY REGULATIONS ON NEW FIBRE SHIPPING CONTAINERS ISSUED BY WPB

The War Production Board recently issued inventory regulations applicable to new fibre shipping containers. Purchasers are directed to cancel or postpone any fibre carton orders that may not be received within inventory limitations.

Direction No. 1 to Order L-317 (Fibre Shipping Containers) clarifies regulations that pertain to inventory and excessive ordering. In issuing Direction No. 1, WPB gave the following explanation of two points covered in it:

"1. (Inventory) Order L-317 prohibits the acceptance of more new fibre shipping containers than the 'maximum permitted inventories' described in paragraphs (o), (p) and (q). But the L-317 provision does not supersede Section 944.14 of Priorities Regulation 1, which prevents the delivery or acceptance of material 'in excess of the practicable minimum working inventory reasonably necessary to meet deliveries of the products of the person accepting delivery, on the basis of his current method and rate of operation.' Therefore, purchase of new fibre shipping containers is limited to permitted inventory under Order L-317 or to 'practicable minimum working inventory' under Priorities Regulation 1, whichever is less.

"2. (Excessive orders) It is prohibited to place orders for more new fibre containers than may be received under inventory regulations. Orders calling for delivery in installments may be placed, if all installments can be accepted within inventory limitations at the time specified by the purchase order. But regulations are violated if the purchaser places orders for more containers than he reasonably expects the condition of his inventory will permit him to accept at the time specified on his purchase order. Intent to cancel or reduce some orders does not permit a purchaser to place excessive orders."

Rated orders for containers are also governed by this regulation, as stated in paragraph (c) (3) of Priorities Regulation 3. Orders not conforming to these regulations must be cancelled or postponed at once, WPB said.

ABSTRACTS OF FOREIGN-OWNED UNITED STATES CHEMICAL PATENTS ISSUED BY ALIEN PROPERTY CUSTODIAN

The Alien Property Custodian has issued a leaflet announcing the completion of a project for publishing abstracts of 7,000 foreign-owned United States chemical patents which have been seized by this agency and which are now being licensed to American manufacturers in accordance with a policy announced about a year ago.

This descriptive leaflet may be obtained from the Office of Alien Property Custodian, Chicago 3, Illinois.

Down thru the Ages..

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TOUGHENED GLASS DINNERWARE AND TUMBLERS NOW USED BY ARMY

Dinnerware made of toughened glass is helping the Quartermaster Corps solve the problem of breakage of plates, cups, saucers, bowls and other articles of mess hall eating equipment, the War Department reports.

The new dinnerware resembles the dinnerware which is traditionally used in Army messes except that it is made of glass. Prior to the development of this new material, the Quartermaster Corps procured a small quantity of toughened, thin blown glass tumblers. Reduction in tumbler breakage was immediately apparent, and in some cases amounted to as much as 50 per cent under the breakage figures for the pressed glass tumblers previously purchased.

This development led the Quartermaster Corps to explore the possibilities of securing items of dinnerware made of this toughened material which would withstand the severe conditions encountered in service, and which could be manufactured in adequate volume. The project was limited to opal glass and the items included coffee cups and saucers, dinner plates, general use bowls and vegetable dishes.

Before quantity procurements were made, tests were conducted on these various items to find how well they would stand up under the rigorous conditions of Army service. While the tests were not comparative, the results were so satisfactory that the Quartermaster Corps felt justified in procuring the glass dinnerware. It was observed that articles made of the new material could be dropped several times without breaking. This was not true of ware previously used.

Extra strength, however, is not the only advantage of this new type of dinnerware. Through the joint planning of the Quartermaster Corps and the glass industry it has been possible to effect considerable savings in weight and thickness, while retaining necessary strength. Glass cups now show a 25 per cent saving in weight; vegetable dishes, 13 per cent; and general purpose bowls, up to 33 per cent. Savings in thickness range from approximately 4 per cent for the glass plate to 22 per cent for the bowl. The decrease in weight and thickness and increase in strength permits these pieces to be packed more compactly, the items being, in consequence, lighter to ship and easier to handle and store. Since millions of pieces of dinnerware are purchased each year, it is obvious that these are real advantages.

In designing the new dinnerware the Quartermaster Corps combined the functions of several pieces in order to eliminate a number of articles previously used. The general purpose bowl, for instance, now has a newly developed cover which makes it serve also as a sugar bowl, mustard pot or pickle dish. Designs for a new pitcher with a cover which may make it useful for several purposes are now being tested, and the entire list of articles is undergoing functional tests with a view to further increase in the uses to which they may be put.

Glass dinnerware has a smooth surface that does not stain or retain odors. It requires, consequently, a minimum of hand washing and, because it is glass all the way through, absorbs no moisture, shows no surface cracking, and is highly resistant to cuts from table cutlery. Creamy white in color, it is good to look at. Another factor which justifies procurement of the new type of dinnerware is its lower cost.

As is often the case in the adoption of a new product either in civil life or for military use the product is taken for granted and not much thought is given to the enormous effort and time put into the development of the particular product.

While glassmen would not be likely to overlook the technological research involved in a development such as the new glass messware it may be well to point out that while, for example, the Corning Glass Works had had plenty of experience in making light glass tableware and had developed its "Double-tough" tumbler to a high degree of efficiency, the manufacture of glass Army messware posed new and different problems. Solution of these difficulties was not merely a continuation of work which had been done on tableware or tumblers.

Although details of the manufacturing process of this toughened messware cannot be given in this brief account, it is interesting to note that to successfully produce the new ware a new batch composition had to be evolved. The acquisition of certain raw materials and the design and manufacture of new equipment and the training of new workers were among the problems which had to be solved under wartime conditions.

The glass manufacturing industry abounds with achievements which have aided the war effort and it should be emphasized that these achievements are not just the result of a few months' work but rather are the result of years of research and product improvement—development work which has given the glass industry the "know how" and made possible these so-called war miracles.

Corning Glass Works produces the bulk of this new Army messware, while the Libbey Division of Owens-Illinois also supplies toughened tumblers.

FIBROUS GLASS BOARD USED FOR SHIP HULL INSULATION

Use by Owens-Corning Fiberglas Corporation of an improved thermosetting plastic binder, employed to bond glass fibers, has made it possible to provide a rigid hull insulating board for Navy and Maritime Commission vessels which, with a density of only seven and three-quarters pounds to the cubic foot, possesses all the thermal insulating qualities of the nine-pound-density board formerly supplied by the manufacturer for this purpose.

This lighter board will effect a material weight saving in the vessels in which it is installed, and because it requires a lesser quantity of glass fibers, will aid the manufacturer in supplying the greatly increased quantities of the board called for by the Navy ship-building program.

An accompanying increase in the manufacturer's output of fibrous glass textiles has made glass cloth available for facing the hull insulating board, thus providing added fire resistance for all types of ships.

• William E. Cash was recently appointed assistant manager of the Glass and Closure Division—Industrial Division Creative Section of the Advertising and Promotion Department of the Armstrong Cork Company.

LOOK TO THE FUTURE *thru Glass!*

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A vital contribution to the new characteristics and forms of high-grade glass is SOLVAY Potassium Carbonates. Their outstanding superiority of granulation and purity are acknowledged by glass manufacturers. If you have an idea for new high-grade glass, consider these high-grade SOLVAY Potassium Carbonates.

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BOOK REVIEW

"Optical Workshop Principles"

by Col. Ch. Dévé (Translated by T. L. Tippell)

The literature on the process of glass surfacing is so small that any addition is cause for considerable interest. The experience of Colonel Dévé is well known and places him in a position of a master of the art with sufficient scientific knowledge to analyze the complex motions involved in this work.

This book opens with an elementary description of glass and its optical aberrations, following with particulars of the many materials used in glass working, including some I was unaware were used, and others I thought were distinctly out-of-date at this time. Paper polishers are described; it must be forty years since I have seen this material used.

Some details of surfacing (or grinding) are explained and this could have very well been extended.

A chapter on the types of spectacle lenses seems strangely out of place in this book.

A chapter on Surfacing compares working on a fixed post, on a pedal or hand lathe and on automatic machines. The automatic machine seems to be the only one that should be considered in these times as production is so small in the other two cases.

The principal part of the book is on the Mechanical Theory of the Working of Optical Surfaces. This is cleverly described in much detail and helps one appreciate the complexities of the process. In describing Systems of Surfacing, the various movements are divided into five classes, some of which are referred to as of equal wear. A system of equal wear should be one in which after prolonged use, both glass and tool retain the desired curvature. For instance, I have a record of a smoothing (fine grinding) tool that ground 550 blocks of lenses on an automatic machine before the tolerance on curvature was exceeded. No adjustments were made to the machine during this run. This is approaching the practical condition of even wear. The movements described in this book as of even wear may be so for the glass but are not for the tool, and it does seem necessary to have equal wear on both glass and tool before a stable condition is obtained.

It would have been interesting to have continued the theorizing to show the very low efficiency of grinding lens surfaces with loose abrasive against metal tools. Such an investigation might well encourage more people to follow the methods used by the mechanic in obtaining true surfaces efficiently. It is in this direction that progress will be made, and the fact that the optical worker must be more precise should not deter us from learning from the machine tool makers what is possible in this line.

The reader must not expect to find any workshop practice in this book. It is distinctly what the title implies, "Workshop Principles." This omission of practice seems to be somewhat of a weakness. The practical application of the principles enunciated would have clarified many points.

There are chapters on optical tests, on polarization, centering and several other allied processes, all of considerable interest but of ancient usage.

There are no new principles or methods given; the basis of this book is the workshop practice of 1910 and as such is very interesting. It is of distinctly theoretical rather than practical value.

A review of a technical book calls for criticism and the foregoing criticism is intended to be constructive. There is much of solid interest in this book and it can be recommended as a useful addition to the very small library of books on this subject.

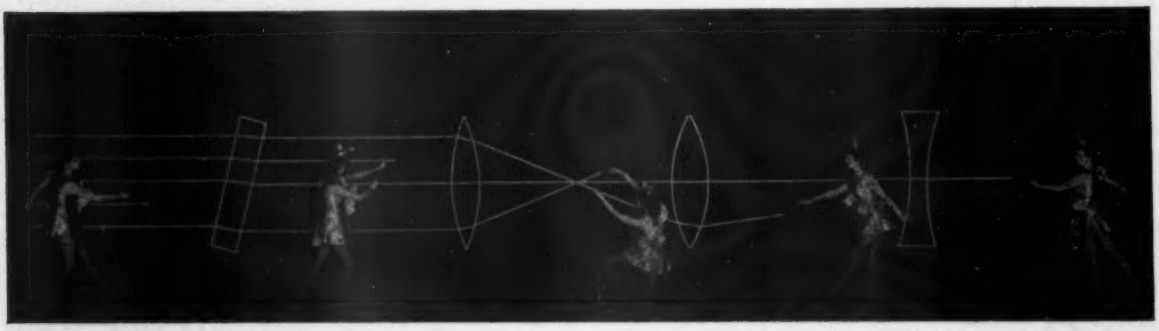
R. S. Guilford

• The International Nickel Company in New York has announced that Dr. V. N. Krivobok, recognized authority on stainless steel and former Professor of Metallurgy at the Carnegie Institute of Technology for many years, has joined the staff of their Development and Research Division.

"Dawn's Early Light," an elaborate stage production, recently paid tribute to Bausch & Lomb war workers. The attraction was staged by and for the employees of the company and six performances were given in Rochester's Eastman Theater.

The illustration shows one of the most novel features—a a ballet number entitled "Bright Miracle" which dramatized the science of optics. On a blacked out stage, the dancers, with fluorescent ribbons, traced the paths of light rays through various lens forms. At the end, a white ray traversed a prism and dispersed into a brilliant spectrum.

Tribute was also paid to the 2,630 company employees now in military service, including 15 who have given their lives, as well as to their parents. The attendance at the six performances exceeded 21,000.



(*Continued from page* 216)

rate of attack is accompanied by a far less effective film, and a superior quality of resistance appears just in the composition range of the best crown glasses, that is, at about 68 per cent SiO_2 in soda lime glass. The boundary of class I in this type of glasses is at about 60 per cent SiO_2. In a pure alkali silicate glass another sudden change (to the worse) occurs when the first R-O-R neighborhoods are established by high alkali (R) concentrations.

As this role of the network forming oxides was applied over a wider range of elements, W. Fraser and one of the authors were able to develop barium crowns of somewhat improved resistivities (*e.g.* from Calgon class 10 h to 100 h or even to class 5 proper).

The complete solution of glass by HF and other fluorine compounds is caused by the formation of SiF_4 and silicofluorides together with the fluorides of the weaker cations. The attack is particularly low in some silica free glasses. It is high if water permits the solution and the removal of the crystalline fluorine compounds some of which have relatively lower solubilities. The presence of common ions with these compounds in the solution, coming either from the glass or from a bath component, prevents the complete removal and mat etching takes place in a way first explained by Tillotson. Upon this principle may be based variations in the bath to suit the wide variety of optical glasses.

If the presence of liquid H_2O is avoided, the new compounds seem to persist as a new layer which is highly skeletonized and has a very low refractive index. This process was discovered and first used by Nicoll. Present researches attempt to locate areas of composition where the glass is reactive to these vapors but not to acid leaching. The exchange of Na_2O for SiO_2, for instance, facilitates HF vapor filming but also acid leaching, that is, it also impairs resistivity. The desire to obtain reactive glasses for certain purposes distinguishes the aims of chemical research in the optical industry from the usual desire of the container industry to have the glass generally inactive. B_2O_3 was demonstrated to be one example where the influence on acid leaching and HF vapor filming is contrasting.

Most procedures for removing surface dirt from finished lenses come under the heading "alkaline attack." The use of organic solvents has been used more frequently in modern cleaning departments. The three main cleaning problems in production are removal of: (1) organic materials, (2) polishing materials, (3) water.

Organic materials (blocking waxes), usually bonded by weak (dipole) forces, are removed by organic solvents and their vapors. Chlorinated solvents are preferred to xylol and benzol because they do not present a fire hazard. Alkaline cleaners would be equally efficient above 80° C, but at this temperatures most glasses are attacked by alkali. At 50° these cleaners are safe but require much agitation to remove the dirt. Coatings used in storing are removed more easily.

Polishing materials, like rouge, present the most difficult cleaning problem. Much agitation is required at temperatures low enough to prevent dissolution of glass. Still adherent rouge is soaked in alkaline solutions containing a wetting agent. Thus loosened, it may then be removed with a towel. Mineral acids cannot be applied except to glasses of perfect acid resistance.

The water films formed after cleaning are removed by: (a) silica smoke, i.e. by a protective layer of finely divided SiO_2 which is wiped off before the final use of the piece of glass, (b) alkaline wiping. Alkalinity increases the capacity of cloth to adsorb water, (c) organic vapors miscible with water.

In the case of the surface after cleaning two extreme requirements are distinguished: (1) an HF dip may remove the surface films and prepare a surface similar to the interior of the glass for fusion. In this process the appearance of polishing defects is enhanced. (2) An acid treatment deliberately sets up a more resistant surface film.

In discussing the mechanism of attack it was pointed out that Geffken's concept, adsorption of Na+ and OH — precedes the isolation of Si — O_4 groups and their removal from the glass. The analysis of the rate of alkaline attack is in favor of this two step concept. The presence of other ions complicates the attack. As little as 10^{-4} mole per L BaO and Al_2O_3, inhibit the reaction of glass with alkali. Commercial cleaners, and many containers, are so infected with ions that deliberate attempts to regulate the attack this way have failed so far except in platinum equipment.

Phosphate and carbonate containing constituents are more destructive in contact with high R^{II} glasses like barium crowns. Alkaline phosphates are generally more aggressive because phosphates attack silica and silicates.

The enormous increase in attack found by Hubbard and Hamilton at low pH near neutrality is doubtless due to the "infection" with anions from the universal buffer solution used. Many cleaners, however, were most reactive with glass at the lowest concentrations tested.

Deterioration of Glass in Tropical Use. *By Frank L. Jones, Bausch & Lomb Optical Company.*

The high humidity, encountered during at least part of the year, in many tropical regions is detrimental to glass. In the presence of water vapor or condensed moisture, the more soluble constituents of the glass migrate to the surface. If no liquid water is present, a slight surface haze develops due to the presence on the surface of extremely small crystals of alkali salts. In tropical climates, conditions are sometimes so balanced that just enough water collects on a glass surface to form a concentrated solution of these salts. Such a solution may attack the silica of the glass and pit the surface permanently. If the glass surface is frequently rinsed with rain, the soluble salts will usually be washed off and the only result of exposure will be the formation of a surface layer rich in silica and low in alkali.

The growth of fungi or molds on glass is a much more serious source of trouble than the effect of water alone. Glass, itself, is not a food for fungi and little damage results if organic materials are excluded from the environment. In tropical regions, however, the dust in the air is organic in nature and contains spores of various molds. Small insects or insect-like organisms are universally distributed. Mites, in particular, will move onto a glass surface, live and die there in great numbers, and their bodies will form a center for fungi to develop. The hair-like filaments of fungus growth cover the surface and obscure vision, in many cases rendering the surfaces of lens and prisms opaque. The solutions held against the glass by fungus filaments may be initially acid and later alkaline as the fungus is in turn decomposed by bacteria and soluble salts are leached out of the glass. Glasses low in silica may be badly etched by contact with fungus growth.

The damage from fungus growth on glass is not great if the glass is cleaned at frequent intervals. Glass lenses or prisms that are enclosed in instruments in such a manner that cleaning is not practicable, should be adequately sealed to prevent the entrance of moisture, insects or molds.

Precision Apparatus for Rapid Determination of Indices of Refraction and Dispersion by Immersion. *By Conrad A. Faick and Bernard Fonoroff, National Bureau of Standards.*

In the production of optical glass, careful control over the optical properties of the product is essential. In times of heavy production it is especially desirable to have testing procedure that is accurate, speedy and easy to manipulate.

A new immersion method developed to meet these needs was described. The method which is used for both indices of refraction and γ values employs a double-diaphragm for securing oblique illumination.

The average error in the determination of indices of refraction, based on 144 measurements, was 2×10^{-5} and the maximum error was 5×10^{-5}. Complete measurements of the indices of refraction for the sodium D line and the

(*Continued on page* 232)

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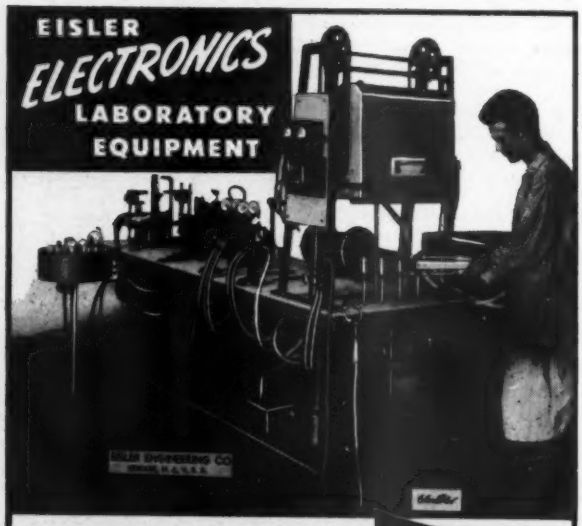

This electronic tube making unit fills the needs of schools, colleges, experimental and research laboratories for a compact machine complete in itself and capable of performing all operations required in the construction of incandescent lamps, radio tubes, electronic tubes and similar devices.

WRITE FOR CATALOG No. 43-B

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THE GLASS DIVISION . . .

(*Continued from page* 231)

hydrogen C and F lines may be made in approximately 1½ hours, and with these measurements the γ values may be calculated with an average error of 0.1 and a maximum error of 0.8.

Variations of Refractive Index of Glass with Time and Temperature in the Annealing Region. *By Harold McMaster, Libbey-Owens-Ford Glass Company.*

The refractive index of a small rod borosilicate glass which had been suddenly chilled from a softened condition was more than .0070 lower than the fine annealed index of the same glass. When the glass rod was inserted into a furnace held in the range 900° F to 1100° F, its index increased with time, t, according to the equation

$$\frac{1}{N_\infty - N} - \frac{1}{N_\infty - N_0} = At,$$

where N_∞ is the equilibrium index and A the rate constant characteristic of each temperature. The equilibrium index, N_∞, changes with temperature in almost linear fashion in the region studied. The variation of rate, A, with temperature could be well represented by the equation

$$\text{Log } A = \frac{K}{T} + C,$$

where T is the absolute temperature and K and C are constants.

These equations can be used to calculate the time that must be spent at each temperature to reach the highest index in a given time. Cycles can also be devised to give a very uniform index for high precision optical glass.

These equations are also of theoretical interest since they have the form of second order reaction and rate equations in theoretical chemistry.

Non-Reflecting Films. *By Frank L. Jones, Bausch & Lomb Optical Company.*

The use of non-reflecting films on the glass surfaces of optical instruments has increased greatly during the past two years. Films made by acid leaching the glass surface were discovered in 1892. In 1936 the production of films by high vacuum evaporation was developed. Little commercial use of non-reflecting films was made until 1940 when one manufacturer introduced coated projection lenses and another manufacturer applied films on an expensive camera lens. Since 1940 the percentage of instruments made with film coated lenses has increased until reflection reducing films are the rule instead of the exception. In some cases, the gain in light transmission of the instrument due to the reduction in the percentage of light reflected from each glass-air interface is less important than the improved visibility for small, dark objects against a bright background.

The number of methods available for producing thin, transparent surface films has increased as fast as the interest in the subject. If the number of transparent solids available in nature were multiplied by the number of methods by which a thin film of uniform thickness could be applied to a glass surface, the product would be a very rough estimate of the number of processes that could be developed for making anti-reflection films. These transparent solids may be either porous or non-porous. Multiple layers of high and low refractive index solids may be used.

Each type of film has its advantages and disadvantages. For the duration of the war there is little doubt that evaporated fluoride films will be most generally used because of the obvious advantages gained by standardization. In general, the hardest and most durable films are not the

most efficient in reducing reflection. In the post war production, it seems likely that each manufacturer will use several types of anti-reflection coating. The film will be selected to match the type of use to be encountered in service. The coatings will probably fit one of the following classifications:

I. Transparent Thin Films Applied Over a Glass Surface
   A. Films From Monomolecular Layers
   B. Films Deposited From Liquids
      1. From Colloidal Systems
      2. From Solutions of Film Material
      3. From Solutions of Compounds That Will Decompose to Produce Film Material.
   C. Films Deposited From Vapors
      1. From Vaporized Film Material
      2. From Vaporized Compounds That Will Decompose to Produce Film Material.

II. Transparent Thin Films Produced Within the Glass Surface
   A. Films Produced By Chemical Reactions With Liquids
      1. By Ion Exchange Between Water Solutions and Glass
      2. By Ion Exchange Between Fused Salts and Glass
      3. By Selective Solution of Glass Components to Produce Porous Surface.
   B. Films Produced By Chemical Reactions With Vapors
      1. By Ion Exchange With Vapors
      2. By Selective Decomposition of Glass Components to Produce Porous Surface.

Optical Glass from Viewpoint of Lens Designer. *By R. Kingslake, Eastman Kodak Company.*

To the lens designer, optical glass is merely a convenient transparent material having certain specified values of refractive index and dispersion from which it is possible to make lenses. He assumes that the glass which is available to him is colorless, stable to atmospheric weathering, and free from obvious physical defects such as striae and large bubbles. The chemical composition, method of manufacture, and its chemical and physical properties are of no interest.

Because practically every new lens must be achromatic, the positive elements used in it must be made from glass having a low dispersive power and the negative elements must have a relatively high dispersive power. The correction of lateral color is accomplished by securing a proper balance between the elements ahead of the stop and behind the stop.

The choice of refractive index is determined by many conflicting factors inasmuch as the only "tools" available to the designer for the correction of many different aberrations are the radii of curvature of the lens surfaces, the thickness and air spaces, and the refractive indices of the glass.

The range of optical glasses available in this country and their optical properties was given. The reasons underlying the designer's selection of glass for different kinds of lenses including anastigmat, achromat and others were discussed.

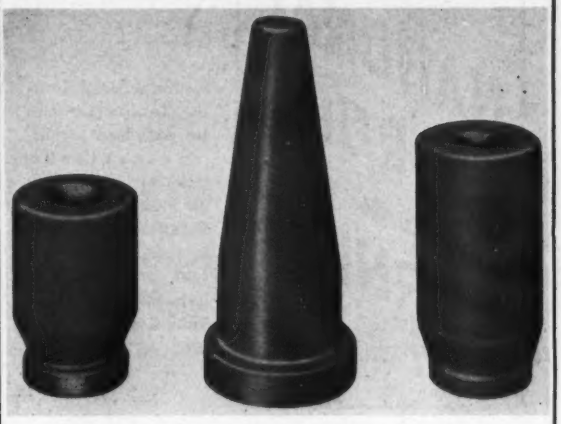
It was stated that with the present day development of some entirely new kinds of optical glass, we may see almost a revolution in lens design during the coming decade; but as no tool works by itself, a new and better lens must ever remain a monument to the patience, skill and tireless energy of the lens designer.

Time Problem in Annealing. *By Aniuta Winter, Ecole Libre des Hautes Etudes.*

The problem of glass annealing is a problem of physico-chemical equilibrium. The best annealed glass is the glass which is in equilibrium at the temperature at which it is used and may be called stabilized because it will not vary with time. This maximum of stabilization is needed only for

(*Continued on page* 234)

Gunite A-CCA For Moulds



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THE GLASS DIVISION . . .

(*Continued from page* 233)

a few uses of great precision. For many other purposes, a glass less stabilized can be used if it is sufficiently homogeneous (i.e., structually homogeneous).

The study of variation of refractive index of a glass as a function of temperature and time in the transformation region permits the determination of the shortest annealing schedule necessary to reach a given refractive index and a given degree of homogeneity. The speed of variation of refractive index at constant temperature changes rapidly with temperature in the transformation regions. Equilibrium is reached in a few minutes near the upper limit of this region, but several hundred hours are required at the lower limit. By making proper use of this rapid variation of the speed of transformation within relatively small limits of temperature, an annealing schedule can be established to obtain a fairly high degree of structural homogeneity without reaching the highest value of refractive index but with enough stability for many practical purposes. This can be done by freezing the glass at a certain state of equilibrium corresponding to a temperature at which the transformation is slow enough to be neglected during the subsequent rapid cooling. This method of freezing for annealing is represented by the curve shown in Fig. 1. The usual form of annealing curve is shown in Fig. 2.

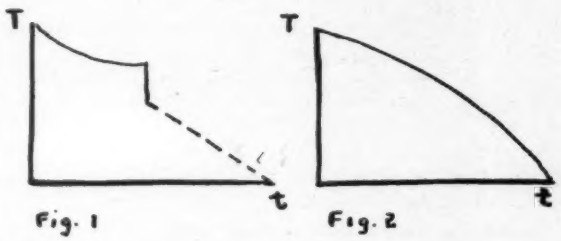

Fig. 1 Fig. 2

The form of the curve in Fig. 1 has the following objections:

1—The curve is not taking advantage of the fact that at the higher temperature the equilibrium is reached faster.

2—It leads more easily to the lack of structural homogeneity because the gradient of temperature increases with the rate of cooling and therefore this curve is larger at the end of the annealing than at the beginning. The opposite is true for the other curve. It is only necessary to take great care that equilibrium be reached when the freezing process starts.

This method of annealing allows a considerable gain in time and permits the attainment of an adequate degree of structural homogeneity.

Observations on Fuel Oil Consumption in Similar Container Glassmelting Furnace. *By K. C. Lyon, Armstrong Cork Company.*

In this report the results of an analysis of Bunker "C" fuel oil consumption in three similar glass furnaces melting flint container glass over a period of several campaigns was presented. The furnaces were similar in design and construction, being three-port regenerative furnaces fired by oil fed beneath the ports. The melting end had an area of 408 sq. ft. while the working end had an area of 130 sq. ft. The glass depth was 32 inches in the melting end and 20 inches in the nose. The furnace bottoms are cast clay block, the sidewalls are electrocast block, while the upperstructure and crown is silica. The melting end temperature measured by a thermocouple in a crown block varied from 2627 to 2752° F. The effective average temperature over the past four years of operation was 2681° F.

The daily fuel consumption and glass tonnages (calculated from the amount of batch fed) were assembled on a monthly basis and subjected to an algebraic calculation to determine

the line of best fit. Such plots show that the slopes of the lines vary for different months and that this has an effect on the amount of oil needed to maintain the furnace temperature at no load.

From this data charts were constructed which showed: 1 — the oil required to melt sixty tons of glass against furnace life; 2 — the variation in gallons of oil required to melt one ton of glass; 3 — the variation from average practice and effect of cullet usage and calorific value of oil; 4 — the effect of furnace temperature on oil consumption; 5 — the effect of bridge wall temperature on oil consumption, and 6 — the variation from average practice corrected for tank temperature.

This data was compared with the data previously reported by Newman. Newman found that 16.9 gallons of oil (data converted to oil from 1050 B.T.U. gas) are needed to melt a ton of glass compared with 14.9 gallons in this investigation. It is possible that differences in glass batches may account for part of this discrepancy. Newman indicates that 1852 gallons per day are needed initially to maintain a tank temperature at 1414° C bridgewall with no load for a furnace of 408 sq. ft. melting area. The present study indicates that 2002 gallons are needed to accomplish this same condition in tanks of the particular construction studied.

Newman also found that 4.16 gallons are needed to maintain a one degree temperature change for a day. This work indicates that 3.68 gallons are required. The monthly aging factor reported by Newman was 42.8 daily gallons per month increase. For the tanks studied this factor was determined to be 41.6.

Application and Results in Use of Automatic Control in Glassmelting Furnaces. *By W. H. Hasselbach, Libbey-Owens-Ford Glass Company and F. E. Early, Askania Regulator Company.*

The application of modern automatic control equipment such as combustion and furnace pressure control was described.

Furnace pressure control is a mechanism for the purpose of automatically maintaining a constant and uniform pressure inside the combustion chamber of a furnace and is accomplished as follows; an opening is made through the furnace at a point of average pressure inside the furnace. The existing pressure is then felt through this opening and is directed to the sensitive element of the regulator through the impulse connector. Changes in furnace pressure cause the regulator to operate a power unit which in turn regulates the stack damper in such a manner that the furnace stays at the desired pressure.

Combustion control is a mechanism for the purpose of maintaining a predetermined ratio between the rate of flow of fuel entering a furnace burner and the rate of flow of combustion air entering the burner port. It is applicable to either gas or oil fired furnaces if equipped with force draft fans. Combustion control is accomplished by 1 — the gas or oil entering the burners is measured but not regulated,

(*Continued on page* 238)

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ETERNAL AS THE SANDS OF TIME
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NEW GOVERNOR FOR AIR COMPRESSORS

The Army Ordnance Department is attempting to secure an inventor's patent for a young Ordnance mechanic who, in his spare time, developed a new way of conserving a piece of automotive field equipment and saving critical gasoline.

The Simpson control governor, named after Sergeant Ernest Simpson of Gettysburg, Pennsylvania, now attached to the 874th Ordnance Company at Fort Dix, New Jersey, is a clever device that can be attached to the air compressor units now used in the United States and in all overseas theatres.

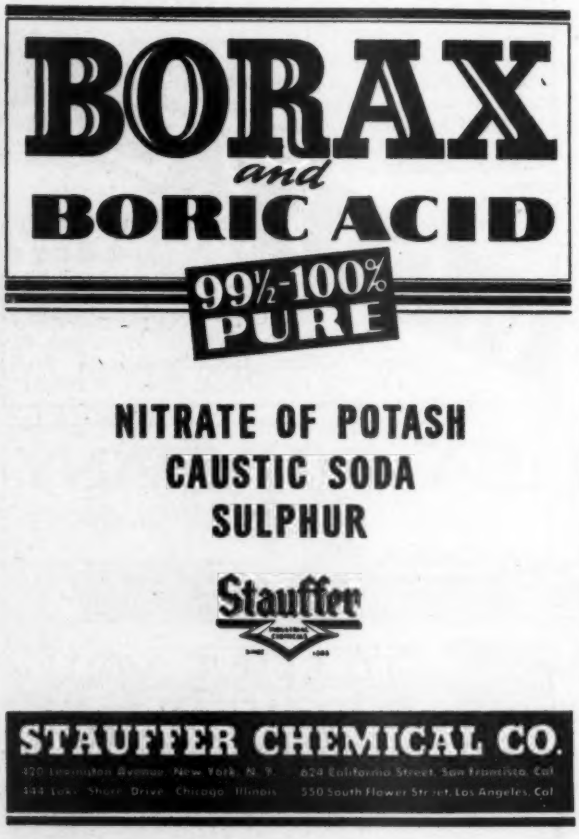
The principal function of the device is to reduce the speed of the engine when the compressor is not under load. When attached to a small mobile air compressor, the idling speed of the engine can be reduced 34 per cent, gasoline consumption slashed 15 per cent, and exhaust temperatures decreased 13 per cent.

Used on the large air compressor (16 cubic feet), the idling speed of the engine can be reduced 30 per cent, gasoline consumption cut 11½ per cent, and exhaust temperatures decreased 2 per cent.

Proving ground tests on the device have been completed at the Ordnance Proving Ground at Aberdeen, Maryand, and the usual field tests will follow.

It is expected that the Simpson control governor will greatly prolong the life of air compressors, reduce maintenance and repairs, and save valuable cargo space that would otherwise be used to transport gasoline.

Sergeant Simpson has been in the Army three years, and his invention represents a year's work—from August, 1942, to August, 1943.



INVENTIONS AND INVENTORS . . .

(*Continued from page* 221)

advantages include its non-marring action, its allowance for unretarded expansion and contraction of the glass and its adaptibility to plates of any thickness.

In patent 2,345,336, John H. Fox of the Pittsburgh Plate Glass Co. describes a bullet-resisting safety glass shield for an aeroplane cockpit housing. It is built up from numerous laminae of glass and plastic into the shape of a truncated cone with the base outward. The shape of this shield and its tight armored housing tends to exert a compressive force on each sheet of glass counter to the expansive action which would normally result when the outer layers are penetrated by a bullet.

Another Pittsburgh Plate Glass Co. patent is 2,345,356, the invention of Wm. Owen of Pittsburgh. This is a process of silvering a glass plate to form a mirror by applying a stannous chloride solution to one surface of the plate as a sensitizing agent, then rinsing the surface and applying a silvering solution to deposit a film of silver, and contacting the other surface with water during at least one of the operations in order to prevent the deposition of the silver on this surface.

Glass Wool and Fiber

William M. Camp of Glen Ridge, N. J. received and assigned to The Clark Thread Co. a patent 2,344,494 for the manufacture of glass thread which is said to have great pliability, and which can be easily used in ordinary sewing. The method consists in impregnating glass fiber thread with latex and then passing it through the orifice of a die heated to about 350 degrees, which results in a vulcanizing action while the thread is being compressed for passage through the die.

In patent 2,344,601 assigned to the Owens-Corning Fiberglas Corp. by Howard W. Collins of Newark, Ohio, means are described of making a so-called high density bat from glass wool. This means a bat having for example a weight of 12 pounds per cubic foot. Collins deposits the newly formed fibers on a conveyor belt, then passes heated air downward through them to move them toward the conveyor, and in a final step reverses the direction of air movement while the matting is simultaneously being compressed. The downwardly moving air is used for preheating and does not soften the glass, but the air which moves upwards is hotter and actually softens the fibers so they will coalesce.

In another Owens-Corning Fiberglas patent, 2,344,892, Piero Modgliani and Valentino Wiquel of Leghorn, Italy, describe a method of making strips of artificial fibers by winding the fibers helically on a drum support and progressively cutting a continuous spiral strip of predetermined width from this drum and rewinding it on another spindle.

● The third National Chemical Exposition, sponsored by the Chicago Section of the American Chemical Society, will be held November 15 through 19, 1944, at the Chicago Coliseum. Headquarters for the show have been opened at 330 South Wells Street, Chicago, Illinois.

ELECTIONS AND NEW APPOINTMENT ANNOUNCED BY WICKWIRE SPENCER STEEL COMPANY

Mr. R. T. Dunlap and Mr. E. F. Early were recently elected Vice Presidents of the Wickwire Spencer Steel Company at a meeting of the Board of Directors.

Mr. Dunlap was previously Assistant to the President and for the past several months has been acting in the capacity of General Superintendent at the company's Buffalo plant. Mr. E. F. Early, who has long been associated with Wickwire Spencer, is General Superintendent at the Morgan plant of the company in Worcester, Mass. They will continue their present duties and responsibilities with the company.

Also recently announced by Wickwire Spencer was the appointmen of Mr. Harry E. Roulfs as Labor Relations Manager. He will represent the office of the Executive Vice President in labor relations matters with all company plants, maintain contacts with government agencies and other firms in the steel industry.

FORMER PRESIDENT BECOMES CHAIRMAN OF BAILEY METER COMPANY

At a recent organization meeting of Bailey Meter Company directors, E. G. Bailey, former president and company founder, was elected chairman. Robert S. Coffin succeeds him as president.

Mr. Coffin, who has been vice president since 1925, became associated with Bailey Meter Company as treasurer at the time of its organization in 1916.

MANAGER APPOINTED FOR NEW FELKER DI-MET CHICAGO OFFICE

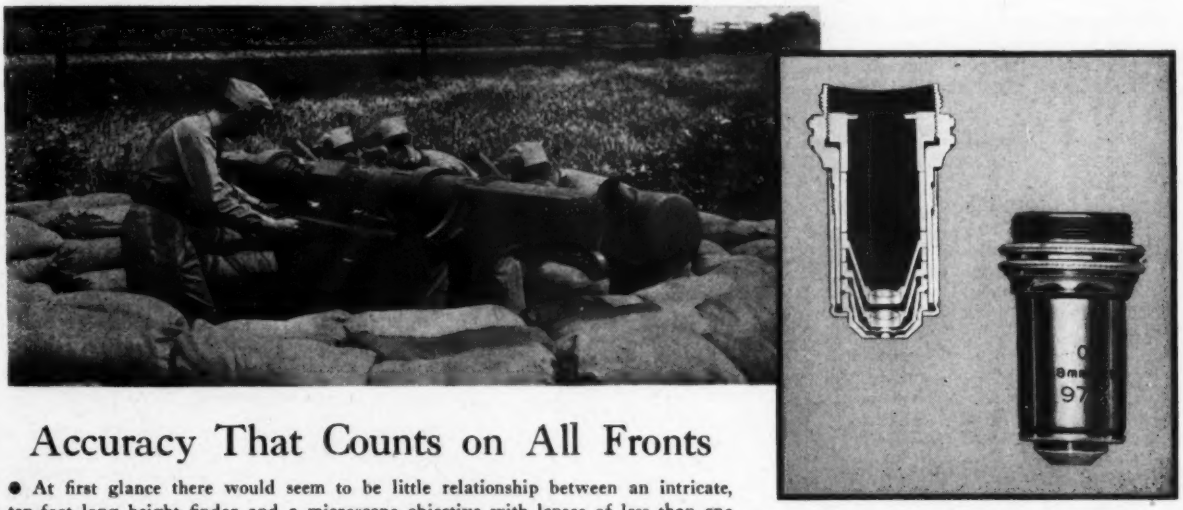
The Felker Manufacturing Company, Torrance, California, has announced the appointment of Fred Bell Jr. as manager of the recently opened Chicago office. He will supervise the sale of Di-Met Diamond Abrasive Wheels and Di-Met Machines throughout the Chicago area.

Before joining the staff of Felker Manufacturing Mr. Bell was associated with the Dole Valve Company and the Hydraulic Hoist Manufacturing Company.

M. E. CLARK RESUMES DUTIES WITH WYANDOTTE CHEMICALS

M. E. Clark, former manager of Market Research for Michigan Alkali Company, has returned to Wyandotte Chemicals Corporation as Assistant Director of Technical Service and Manager of Market Research.

In July of 1941 Mr. Clark was granted a leave of absence at the request of the Office of Price Administration to accept special duties in Washington, where he later became Chief of the Program Section of the War Production Board.



Accuracy That Counts on All Fronts

● At first glance there would seem to be little relationship between an intricate, ten-foot long height finder and a microscope objective with lenses of less than one millimeter in radius. Yet both are the products of the same eyes, the same facilities, the same standards of accuracy, the same experience. Both are aiding in America's war effort. Both are products of Bausch & Lomb.

The lens computing and grinding skills that for years have produced the minute, exceedingly accurate lens components of the microscope objective are today also being employed in the production of height-finders and gunfire control instruments that are helping America's armed forces to win an earlier Victory.

This quantity production of precision optical instruments, pioneered and fostered by Bausch & Lomb through years af peace, has become a highly valued asset to an America at war. Here again, because of its wartime accomplishments, Bausch & Lomb will be able to extend its optical services to peacetime pursuits when Victory is won.

Bausch & Lomb Oil Immersion Objective
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An American Scientific Institution Producing Optical Glass and Instruments for Military Use, Education, Research, Industry and Eyesight Correction

(*Continued from page* 235)

2 — the combustion air entering or leaving the forced draft fan is measured, and 3 — the rate of flow of the combustion air is then controlled so that the ratio of fuel flow and air flow remains constant. A description of the mechanical operations was given.

A comparison of manual operation versus automatic operation indicated that in the case of automatic pressure control atmospheric conditions are corrected to affect checker resistance, changes in the rate of fuel or air supply, and other such variations. Many of these cannot be satisfactorily corrected by manual adjustments. In the case of automatic combustion control the benefits which result from a continuous and uniform fuel/air ratio are: 1 — the length of the flame is a function of the fuel/air ratio. If a uniform flame is maintained, even temperature distribution throughout the furnace is likely and flame impingement on the opposite port and combustion in the checkers can be avoided, 2 — the temperature of the flame is also a function of the fuel/air ratio, obviously if this condition is continuously maintained, a stabilized furnace temperature will be much easier, and 3 — considerable fuel saving will result if the ratio is maintained at the proper value.

The use of such controls do not displace the tank operator but help him take care of situations beyond his control. For example, proper pressure control minimizes infiltration of air into the tank from locations such as between the breast wall and the side wall blocks. The effect of drafts from one side of the tank or the other may be minimized by maintaining a slight pressure. High furnace pressure may also be responsible for excessive wear of the refractories above the glass line. Operation of the furnace at negative pressures increases fuel consumption due to the infiltrated air which bypasses the checkers.

Fuel/air ratio control has contributed much to a uniform fire and better operating conditions, and has resulted in better glass, economy of operation through larger yield and economy of fuel.

Actual operating experience indicates that such controls are not a cure all but are a part of a large number of elements that can make furnace operation easier, help to produce better glass, and this more economically.

Fume or Vapors from Molten Glass. *By C. A. Bradley, Jr., Corning Glass Works.*

Molten glasses are considered as solutions of more or less volatile constituents, particularly as regards the vapor pressures and the rates of evaporation of the more volatile ones. At the temperatures employed in glass melting and working, considerable amounts of material, mainly fluxes, are vaporized from the melt. Most of the materials which thus distill off have boiling and melting points higher than those temperatures which exist in certain parts of the checker and flue systems. Considerable amounts of these materials will therefore condense out as slag or dust.

The actual experimental work as reported in the literature on the subject of volatilization is not very extensive. The major share has been done by E. Preston and W. E. S. Turner. Applications of Henry's law and the Clapeyron equation to the experimental results obtained by Preston and Turner were made and from the results, the amount of material lost by volatilization (disregarding losses due to "dusting" of the batch) from commercial melting units were calculated.

In the case of a alkali-lead oxide-silica glass (SiO_2 55.57%, PbO 29.83%, Na_2O 5.18%, K_2O 7.60%, R_2O_3 1.29%) it was calculated that the loss of lead by volatilization would be 1.14 lbs./ft.^{2}/day at 1400° C and 0.447 lbs./ft.^{2}/day at 1300° C (2375° F). For a tank with a melting end of 400 sq. ft. and a working end of 150 sq. ft. and assuming that one half of the melting end is not covered with melting batch, i.e., the half toward the bridgewall, with a melting end temperature of 1400° C and a working end temperature of 1300° C the calculated lead loss due to volatilization only would be 295 lbs. per day. As Preston and Turner's experiments were performed in a quiescent atmosphere it is apparent that in a continuous tank or an open pot the actual loss would be much higher than this calculated loss. It can reasonably be assumed that part of the lead oxide will condense as a molten slag and part will deposit as a dry solid somewhere in the checkers or flue system.

In the case of soda-lime-silica glass containing 0.83% SO_3 it was calculated that the volatilization of alkali would be in the order of 0.024 lbs./ft.^{2}/day at a temperature of 1450° C (2640° F) and 0.0082 lbs./ft.^{2}/day at 1300° C (2375° F). With a tank of 600 sq. ft. melting area and a working end of 200 sq. ft. area the total volatilization loss at these temperatures would be 16.04 lbs./day. This amount of material is much smaller than that occurring in the melting of high lead glasses. However, the actual amount of volatilization taking place is probably much greater than these calculated losses. It must also be remembered that this volatilization will take place even though "dusting" of the batch is completely eliminated either by special methods of charging the furnace or by briquetting the batch.

Volatilized alkali and sulphur oxides from sulphur in the fuel can also combine and form sodium sulphate which will condense in the checkers, flues or cooler portions of the furnace. Heavy oil, such as that used for fuel, contains from 0.5 to 0.7% S. With a furnace melting 100 tons of glass per day, at a fuel consumption of 75 gallons per ton, the fuel used per day would be 7500 gallons or 56,000 lbs. of oil per day. At 0.6% this amount of fuel would contain 336 lbs. of sulphur. This sulphur would form 672 lbs. of SO_2 or 840 lbs. of SO_3 for possible combination with any alkali oxides.

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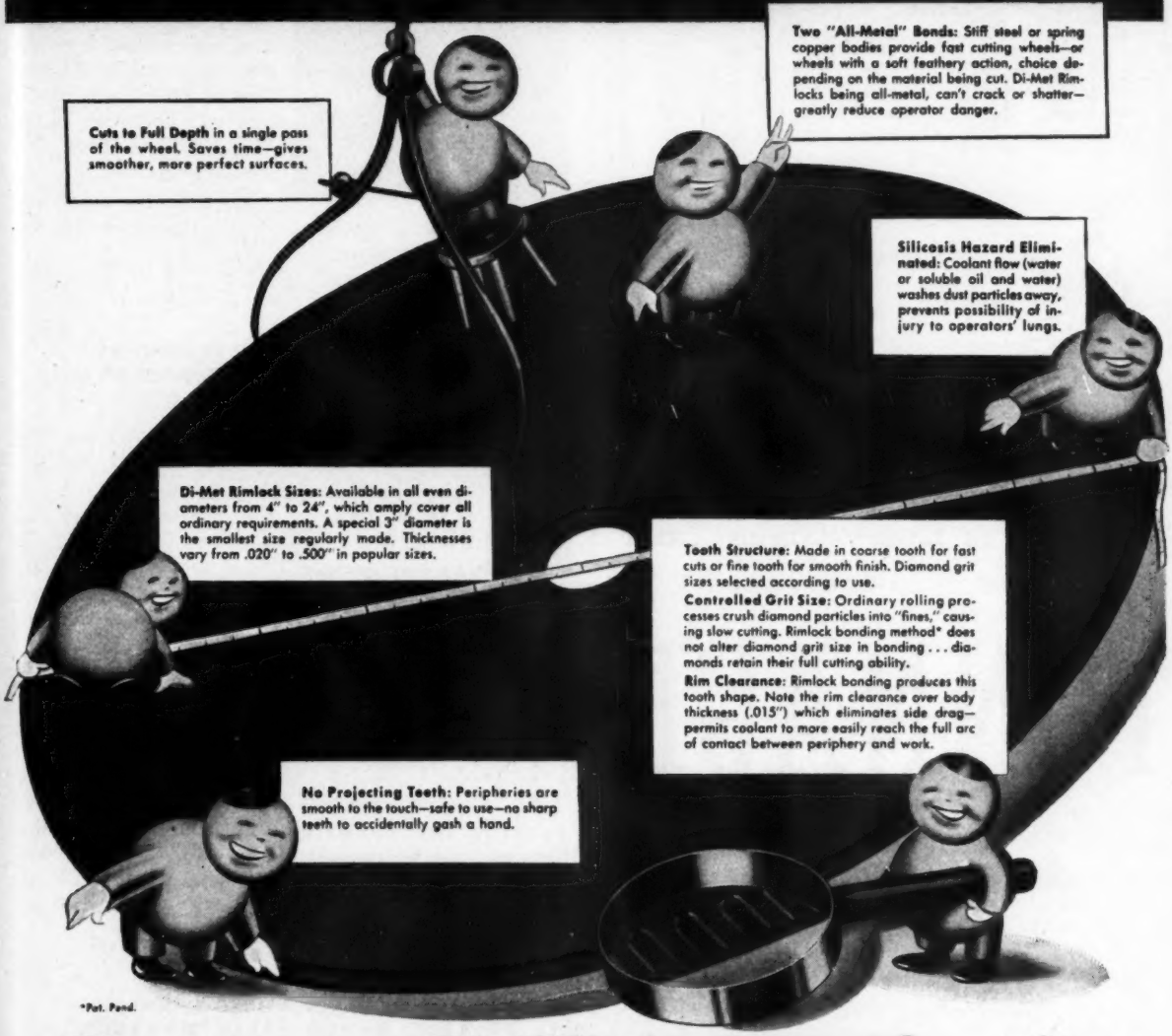

Two "All-Metal" Bonds: Stiff steel or spring copper bodies provide fast cutting wheels—or wheels with a soft feathery action, choice depending on the material being cut. Di-Met Rimlocks being all-metal, can't crack or shatter—greatly reduce operator danger.

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Tooth Structure: Made in coarse tooth for fast cuts or fine tooth for smooth finish. Diamond grit sizes selected according to use.

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*Pat. Pend.

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